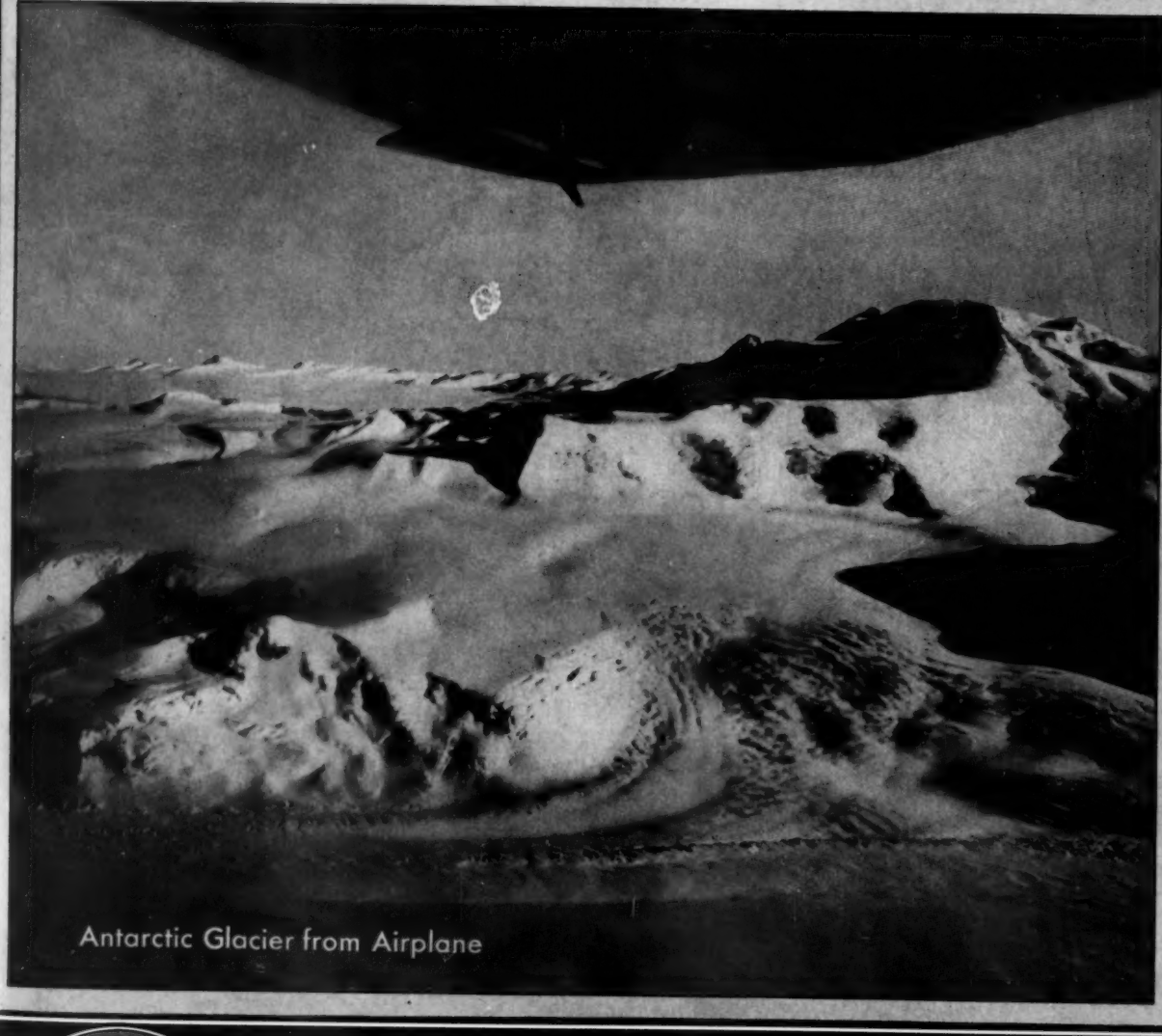
ineering
Library

MECHANICAL ENGINEERING



Antarctic Glacier from Airplane

July 1931

COMBUSTION ENGINEERING CORPORATION

ANNOUNCES

The receipt of the following contracts for

FUSION-WELDED BOILER DRUMS

from subsidiaries of

General Motors Corporation

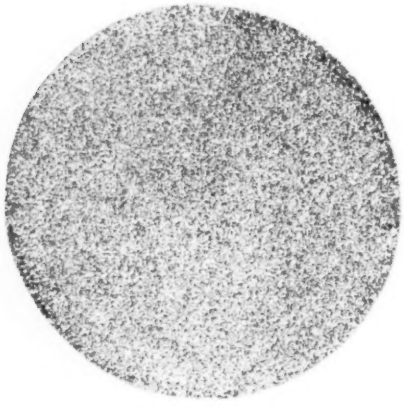
For Fisher Body Corporation —

54 in. dia. drum for 722 hp. boiler,
200 lb. steam pressure.

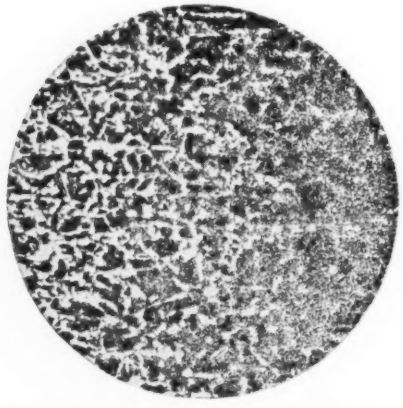
For Fisher Lumber Corporation —

60 in. dia. drum for 887 hp. boiler,
200 lb. steam pressure.

Original metal adjacent to weld magnified 250 times. This is a normal grain structure for steel boiler plates.



H-W-W High-Pressure Weld metal magnified 250 times Note exceedingly fine grain structure.



Junction between original plate and H-W-W High-Pressure Weld metal, showing excellent fusion and complete welding. Note absence of line of junction.

These drums are being fabricated in our Hedges-Walsh-Weidner Shops at Chattanooga, Tenn., by the H-W-W High-Pressure, Fusion-Welding Process. This process is the result of three years' intensive research and development work which has included every practical method of weld testing. In all respects the results have equalled or exceeded the proposed A. S. M. E. Code for welded boiler drums. Full size drums, tested to destruction, have proved the welded seams to have a strength as great, or greater than, the plate itself.

Facts concerning H-W-W High-Pressure Welding Process

Rods used made to our special specifications, to insure uniform high quality of deposited metal.

Only men trained in our welding technique and of proved qualifications are employed in welding.

Procedure control, specifications of rod and facilities used produce welds of unquestionable character.

Ductility of deposited metal slightly greater than that of boiler plate. Ductility of adjacent plate and remote plate unimpaired by weld.

Tensile strength slightly greater than that of boiler plate, but kept in same range as boiler plate.

Deposited metal in weld fused with base metal, without destroying grain structure of base metal.

All drums subjected to hydrostatic test.

All drums are stress relieved in a special furnace of sufficient size to handle practically any drum that can be shipped.

Seams radiographed by powerful new X-ray of latest design capable of X-raying material 3 in. thick and adaptable for X-raying even greater thicknesses.

NEW LITERATURE WILL BE SENT UPON REQUEST

Pending the adoption of the proposed A. S. M. E. Code for welded boiler drums, this construction is offered in non-code states.

COMBUSTION ENGINEERING CORPORATION
200 Madison Avenue New York

Mechanical Engineering

The Monthly Journal Published by

The American Society of Mechanical Engineers

Publication Office, 20th and Northampton Streets, Easton, Pa. Editorial and Advertising Departments at the Headquarters of the Society, 29 West Thirty-Ninth Street, New York
(Cable Address, "Dynamic," New York)

Vol. 53 July, 1931 Number 7

CONTENTS OF THIS ISSUE

Aviation Lessons of the Antarctic ... *Bernt Balchen* ... 489
Research in Industry ... *C. F. Hirshfeld* ... 498
Engineering in Its Relation to the Interstate Commerce Commission ... *Frank McManamy* ... 503
A Russian Engineer on American and German Technique ... 510
A 15,000-Lb. Booster Gas Compressor ... *J. R. Dilley and W. L. Edwards* ... 511
Work-World Environments ... *M. Luckiesh* ... 514
How Coal Market Values Are Related to Steam-Plant Design and Operation ... *G. B. Gould* ... 519
The Present Position of the Automatic Diesel-Electric Plant ... *E. J. Kates* ... 525
Water-Recovery Apparatus for Airships ... *C. P. Burgess* ... 529
Instruments and Apparatus—Part 2—Pressure Measurement ... 542

DEPARTMENTAL

Survey of Engineering Progress ... 531
A Review of Attainment in Mechanical Engineering and Related Fields
Engineering and Industrial Standardization ... 545
Standardization of Clean Coal Is Requested; Standardization a Recognized Means of Stabilizing Employment
Work of A.S.M.E. Boiler Code Committee ... 546
Correspondence ... 546
The Cottonseed-Oil Industry
Editorial ... 548
Research in Power; Industrial Preparedness; S. W. Parr; Every One Can Help; British Steel; Aeronautical Developments; Improved Library Service; Work for the Blind; Spengler—Prophet of Despair; Engineering and Economics at Hartford
Necrology ... 553
Edward Dean Adams
Book Reviews and Library Notes ... 554
William LeRoy Emmet; Preventive Management; Books Received in the Library
Synopses of A.S.M.E. Transactions Papers ... 558
Current Mechanical Engineering Literature ... 559

ADVERTISING

Display Advertisements ... 1
Classified List of Mechanical Equipment ... 34
Professional Engineering Service Section ... 94
Opportunity Advertisements ... 98
Alphabetical List of Advertisers ... 100

Price 60 Cents a Copy, $5.00 a Year; to Members and Affiliates, 50 Cents a Copy, $4.00 a Year. Postage to Canada, 75 Cents Additional, to Foreign Countries, $1.50 Additional. Changes of Address must be received at Society Headquarters two weeks before they are to be effective on our mailing list. Please send old, as well as new, address.

Entered as second-class matter at the Post Office at Easton, Pa., under the Act of March 3, 1879.
Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized on January 17, 1921.

Copyrighted, 1931, by The American Society of Mechanical Engineers

What It's All About

THE COVER PICTURE was taken from Byrd's airplane flying in the Antarctic, and is used in connection with this month's leading article.

:: :: ::

AVIATION LESSONS OF THE ANTARCTIC were brought to the attention of engineers by Bernt Balchen, chief pilot of the Byrd Antarctic Expedition, Associate Member of the A.S.M.E., at the Baltimore Meeting of the A.S.M.E. Aeronautic Division in May. An illustrated abridgment of Balchen's address is the leading article of this issue. It conveys some impression of the meticulous attention to detail that made the Expedition's achievements so successful.

:: :: ::

ENGINEERING IN ITS RELATION TO THE INTERSTATE COMMERCE COMMISSION was discussed by Frank McManamy, Chairman of the Commission, last January for the benefit of the Washington Section of the A.S.M.E. Recently, the newspapers have reported an exchange of views between a committee of railroad presidents and the I.C.C. looking toward possible action in the matter of rates. This gives especial interest to the organization and duties of the Commission and the work of its various bureaus, the engineering features of which are described by Mr. McManamy.

:: :: ::

A 15,000-LB. BOOSTER GAS COMPRESSOR was designed and built for use at the Fixed-Nitrogen Research Laboratory of the Department of Agriculture. The compressor, which is described by J. R. Dilley and W. L. Edwards in the July issue of MECHANICAL ENGINEERING, has a single vertical cylinder with a single-acting plunger-type piston. It has worked successfully on a hydrogen-nitrogen mixture, and is no doubt suitable for other gases, oxygen excepted.

:: :: ::

WATER-RECOVERY APPARATUS FOR AIRSHIPS provides for the loss in weight by the combustion of fuel. When 100 lb. of ordinary aviation gasoline is burned, about 135 lb. of water is produced, and by condensing this from the exhausts of the engines, water ballast is provided. This interesting problem and the features of the apparatus required are discussed in the July issue of MECHANICAL ENGINEERING by C. P. Burgess, Bureau of Aeronautics, U. S. Navy.

RESEARCH IN INDUSTRY is the source from which its progress and prosperity arise. While plants are operating on part time and the immediate future looks dark, research organizations as a rule are being kept intact and spurred to greater efforts, because the results of their work will determine future success. A discussion of this subject by C. F. Hirshfeld, chief of the Research Department, Detroit Edison Company, will be found in the July issue of MECHANICAL ENGINEERING.

:: :: ::

HOW COAL MARKET VALUES ARE RELATED TO STEAM-PLANT DESIGN must be determined by engineers who select and operate coal-burning equipment. G. B. Gould, president of the Fuel Engineering Company, New York, says in the July issue of MECHANICAL ENGINEERING that it is important to determine accurately what limitations on coal selection the plant actually imposes. His observations are important to every one who burns coal.

:: :: ::

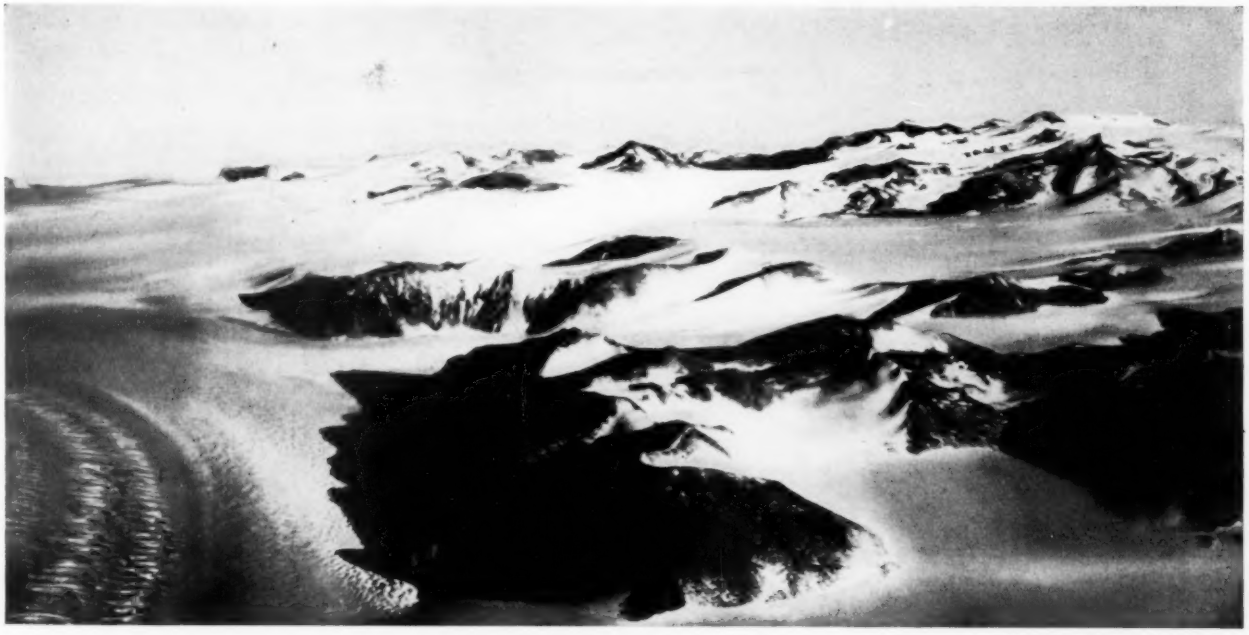
AUTOMATIC DIESEL-ELECTRIC PLANTS have obvious advantages in many cases where power is independently generated by engines and generators that must be started and controlled automatically in accordance with load requirements. Edgar J. Kates, consulting engineer, New York, discusses the present position of such plants in the July issue of MECHANICAL ENGINEERING. Suitable applications of such plants are said to be found in large city buildings, outlying rural sections, county estates, and in combination with other sources of power for emergency and special services.

:: :: ::

WORK-WORLD ENVIRONMENTS, in which many persons spend so many years of their lives, are seldom as favorable to proper mental attitudes as they might be. Light and color, says Dr. M. Luckiesh, director of the Lighting Research Laboratory of the General Electric Company, Nela Park, Cleveland, Ohio, in the July issue of MECHANICAL ENGINEERING, are fundamentally desirable and powerful influences upon happiness. He discusses color schemes for factory machinery and interiors, and the economic value of pleasant working environments that may be greatly affected by light and color.

MECHANICAL ENGINEERING

Volume 53 July, 1931 No. 7



LIV GLACIER—CONTINUATION OF VIEW SHOWN ON COVER

Aviation Lessons of the Antarctic

The Antarctic Region, Its Extent, Elevation, and Climatic Conditions—Flight Problems of the Byrd Expedition as Told by Its Chief Pilot—The Planes Used and Their Equipment—Methods Used in Storing Planes During the Winter Season—Precautions Which Future Parties Should Observe

BY BERNT BALCHEN,[1] HASBROUCK HEIGHTS, N. J.

THE Antarctic region may be generally defined as that portion of the globe south of the 60th parallel of south latitude. It is customary to divide it into four quadrants, namely, reckoning from the Greenwich meridian, the Enderby, Victoria, Ross, and Weddell quadrants. The Byrd Expedition operated in the Ross quadrant. A less precise division into sectors is perhaps more useful for general understanding; the American, African, and Australian sectors denoting respectively the portions of the region to the south of these continents.

The contrast between the Arctic and the Antarctic is striking. Within the area north of 60 deg. there are more than 1,000,000 inhabitants, as well as innumerable land animals. In it are also found some of the largest and most valuable forests, and industries connected with mining, lumber, and fishing. Within the area south of 60 deg., however, not a single human being or land animal has its abode. There are no trees, and very few species of plant life. Whaling is the only industry within the Antarctic regions, and is carried on for about four months every year, chiefly in the American and Australian sectors, and mainly by Norwegian companies. The reason for these contrasts between the Arctic and Antarctic is to be found in the difference between the temperatures of the two areas.

[1] Chief Pilot, Byrd Antarctic Expedition, Fokker Aircraft Corporation of America. Assoc-Mem. A.S.M.E.

Presented at the National Aeronautic Meeting, Baltimore, Md., May 12 to 14, 1931, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Abridged.

SOUTH POLE PLATEAU, LOOKING EAST

Explorations in the 19th century revealed Antarctica as a continent of more than 5,000,000 square miles in extent, equivalent in size to the United States and Mexico. The South Pole is located near the center of this continent, which, though not being symmetrical, may be considered to be bounded on the north by the 70th parallel.

THE ISOLATION OF THE ANTARCTIC

Another feature of the Antarctic is its unique isolation. It is possible to traverse all the other continents without crossing more than 60 miles of shallow water. In order to reach the Antarctic continent, however, one must traverse at least 600 miles of waters of oceanic depths, across the roughest seas and exposed to the fiercest winds in the world. Between 55 deg. and 65 deg. south latitude there is no land to interfere with the west-to-east circulation of the sea and air, and this zone is therefore the home of the westerly drifts, westerly winds, and the wandering albatrosses, all of which encircle the Antarctic continent ceaselessly.

The South Pole itself is situated on a plateau about 10,000 ft. high, and there is every reason to suspect that the greater part of the continent is a continuous plateau. Considering the incomplete data we have today, we can still with some degree of accuracy compute the average height of the Antarctic continent as of the order of 6000 ft., which is about twice as high as Asia. Of this 5,000,000 square miles of area, probably less than 100 square miles are free from permanent snow and ice; and it can easily be understood why it has not been inhabited by man or beast. The continent is still in an ice age more rigorous than that which left its marks on Europe and North America.

The general features of the Antarctic ice cap are practically the same as those found on a smaller scale in Greenland. But the floating ice sheets, which are to some extent derivatives of the ice cap, are met with nowhere else in the world.

When in 1841 Sir James Clark Ross first penetrated the pack ice into the ice-free Ross Sea, he sailed due south until, at about 77 deg. south latitude, he was stopped by a snow wall from 50 to 200 ft. high. He then sailed along the greater part of its 400-odd miles of seaward face.

The Ross Ice Shelf, as it is called, and on which the base of the Expedition was located, is the largest of these floating snow and ice shelves, and is typical of several others encountered in the Antarctic. It is, roughly, the same size as Texas, and consists of a sheet of snow and ice varying in thickness between 500 and 1500 ft., the outer end being open to the ocean, and the inner end held fast to the continent by glaciers, which act as feeders, and by being aground close to the coast.

The surface of the barrier is smooth, as a rule, and forms the easiest approach to the Pole itself since it reaches to within about 320 miles of that point.

Regarding climatic conditions, so much meteorological material has now been accumulated for the American and Australian sectors that it is possible to summarize

ICE TONGUES 70 FT. HIGH IN OPEN WATER. PHOTOGRAPHED FROM AN ALTITUDE OF 3000 FT.

the climate with some degree of certainty. The annual mean temperature seems to be about 10 deg. fahr. lower than that of corresponding north latitude. The lowest temperatures recorded by the Expedition was about 73 deg. fahr. below zero; the lowest ever recorded in the Antarctic was 77 deg. fahr. below zero. As these temperatures were experienced close to the water, it is reasonable to assume that the inland-plateau temperatures in winter are considerably lower. Expeditions in these regions have found that the pressure of the atmosphere increases from the polar circle to the Pole, which is partly due to the form of the continent itself.

WEATHER IN THE ANTARCTIC

Dr. G. C. Simpson made clear by his work that the weather experienced on the outskirts of the Antarctic continent is the result of the passage of pressure waves and the consequent turbulent motion. Such pressure distribution, in connection with the peculiarities of the terrain, produces the most prominent feature of the Antarctic climate: excessively strong winds, which, when accompanied by snow or thick drift, are known as blizzards. Phenomenal records of wind velocity were recorded at Mawson's headquarters at Adelie Land. The mean annual velocity was 50 m.p.h., and occasionally the wind was over 100 m.p.h. for a considerable length of time. Velocities exceeding 220 m.p.h. were recorded.

The winds experienced on Graham Land and Ross Sea were less extraordinary but still of high velocity. At the Rockefeller Mountains a velocity of around 120 m.p.h. was experienced when the Fokker Super Universal airplane, belonging to the Expedition, was blown away. The Bay of Whales was chosen as the base of the Expedition mainly because of its advantages in regard to meteorological conditions.

THE ROUTE TAKEN TO THE POLE

The route from "Little America," as the camp was named, toward the South Pole was practically along the trail laid out by Capt. Roald Amundsen in 1911 when he went to the Pole with his dog teams and skiers. From what our observations told us and from comparing them with Amundsen's data, this base had been located about 3 or 4 miles south of our camp; however, no traces of it were found.

From Little America toward the Pole, the first 450 miles take one over the Ross Barrier. This large snow shelf is mostly flat, with some very gently rolling hills, probably caused by pressure on the shelf. One indication that the Ross Barrier is held back by land is found about 25 miles south of Little America, where the barrier rises from about 200 ft. to about 1000 ft. at 50 miles. The axis of this rise runs from southwest to northeast, and is estimated to be about 50 miles in length. Crevasses to the west, southwest, and northeast indicate some movement of ice about it. In some places where the expansion and contraction changed in direction or magnitude, the plain was

scarred with fissures, cracks, and crevasses, making travel difficult and in many cases dangerous, especially when the crevasses were covered with thin snow bridges, making them in most cases invisible for the traveler on the ground. From the air, however, many of these crevasses could be located on clear days, even when a fairly heavy snow bridge covered them.

The highest point on this route as far as the foot of the Queen Maud Range does not exceed 1000 ft. above sea level. From this point, in a distance of about 60 miles, the mountains rise to a maximum altitude of about 15,000 ft. This range is most likely the boundary of the Antarctic continent in the Australian sector, the lands to the northeast being islands which bound the Ross Barrier to the east. The altitude of the passes into the plateau averages about 9500 to 10,200 ft. Behind the mountain rim the plateau first slopes down to about 8700 ft., then rises to about 11,000 ft., and finally, at the Pole, rises to about 8900 ft. These altitudes are taken from Amundsen's route.

The distance covered from Little America to the South Pole was 790 statute miles, making a round trip of 1580 miles, of which 680 miles had to be flown at an altitude greater than 11,000 ft. to give sufficient clearance over the polar plateau. Had the flight been made at sea level, the distance flown would not have been considered great.

The limiting factors were the maximum fuel load that could be taken to about 11,000 ft. altitude, and the range with this fuel load that could be covered at that altitude.

Preliminary Tests of Planes

In order to get sufficient information as to the performance of the plane type selected for this flight, ceiling tests with three different loads were carried out, in addition to speed tests run over a measured speed course.

The first test was run with a Ford T-A-4 with three Wright Whirlwind J-5 engines. It was found from these tests that the plane did not have sufficient power to attain the altitude needed to clear the lower part of the passes with sufficient fuel to travel from the outside of the Queen Maud Range to the Pole, and back to the mountains. With the data at hand, taking into account the heavier consumption of fuel with larger power plants, it was found that when the center motor was replaced with a Cyclone R-1750 the plane would fulfil the requirements.

With this new installation a speed test was run over a measured course, and load tests with three different loads were made before crating the plane for its journey to the Antarctic.

From the data obtained in the tests it was found that the maximum permissible load to carry when going through the pass at the Queen Maud Range would be about 12,700 lb. gross weight, giving a service ceiling of about 11,000 ft., the bottom of the pass being about 10,200 ft.

The flight was scheduled for a crew of four: a navigator, an aerial photographer, a pilot, and a relief pilot, the latter also acting as radio operator.

A careful estimate of the weights of the different items in the plane ready for polar flight showed the total weight of the plane, crew, and equipment, less gasoline, to be 9278 lb. Deducting this from 12,700 lb. gave a total of 3422 lb. for fuel, equal to 570 gal. of gasoline. Even smaller quantities (559 gal. and 542 gal.) were estimated to be respectively sufficient for a range of 1033 miles at 11,000 ft. altitude with no wind, and a range of 750 miles with a 40-mile headwind.

The distance to cover at this altitude was about 680 miles, so in the worst case the plane carried sufficient fuel to make the flight feasible provided a gasoline depot was laid down at the foot of the Queen Maud Range for refueling on the return flight from the Pole.

For the distance from Little America to the Queen Maud Range the average speed of about 104 m.p.h. for the weight interval between 13,000 and 15,000 lb. gross weight was taken, and consumption for this speed laid as a base for taking fuel on board for this distance (64 gal. per hr. for 4.33 hours = 277 gal.), making a total weight at take-off of about 14,360 lb. The fuel depot at the foot of the Queen Maud Range was flown to on November 18, 1929, and 255 gal. of gasoline and 25 gal. of oil (all in 5-gal. tin cans), a vertical blow torch for heating the engines, 300 lb. of food, and a primus stove were left there. The depot was marked with an orange flat.

The take-off for the polar flight was made on November 28, 1929, at 3:30 p.m., the gross weight of the plane being as follows:

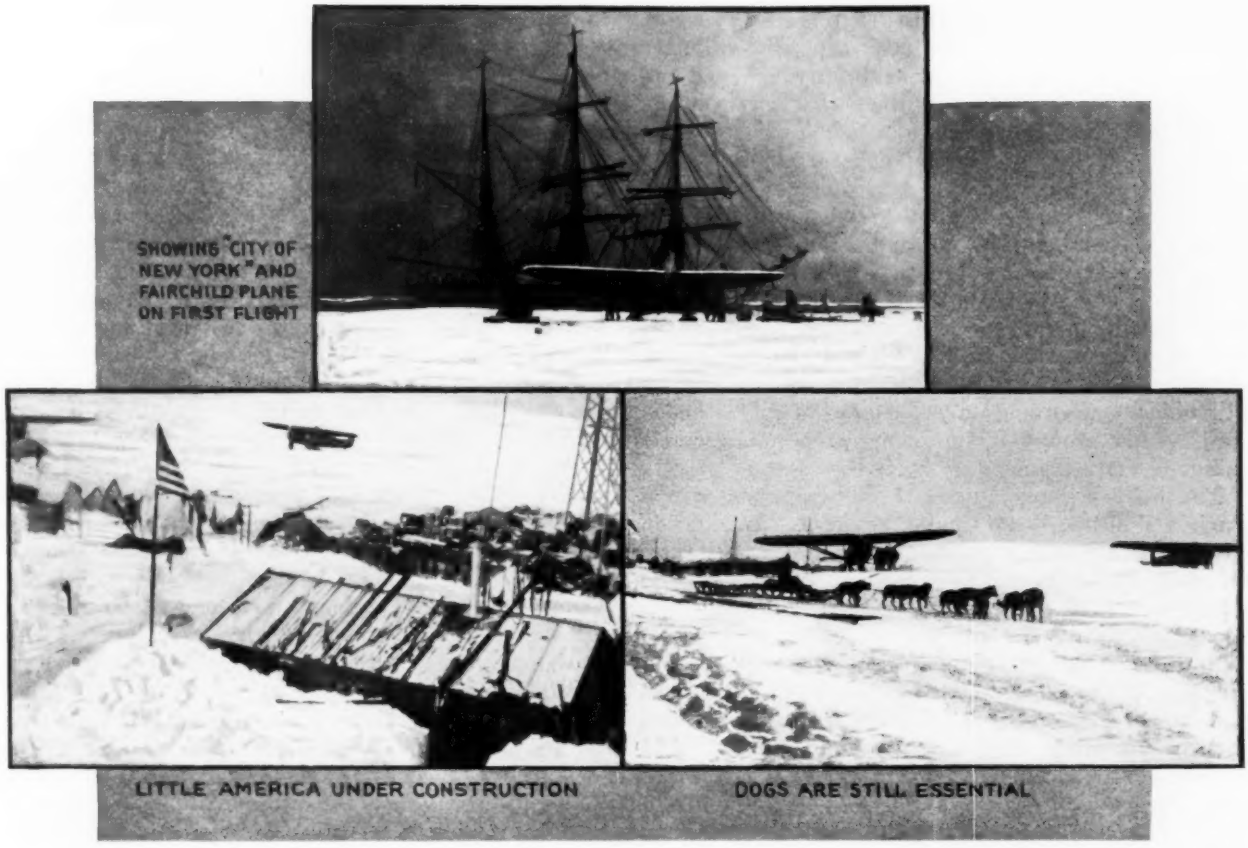
	Pounds
Plane empty on skis	6,700
Gasoline in tanks	4,450
Gasoline in cans	650
Oil in tanks	200
Plane equipment[1]	195
Navigation equipment[2]	40
Radio equipment	175
Photographic equipment	139
Camp and trail equipment[3]	216
Spare clothing	75
Sleeping bags	86
Food	778
Crew	674
Total	14,378

[1] Three motor covers, 50 lb.; three motor heaters, 60 lb.; lashing gear, 34 lb.; spare part for motors, 6 lb.; tools, 26 lb.; 20 smoke bombs, 10 lb.; furs for floor of plane, 9 lb.; total, 195 lb.

[2] Two boat compasses, 20 lb.; two sun compasses, 4 lb.; one sextant, 8 lb.; one drift indicator, 0.5 lb.; one pelorus, 2 lb.; canvas bag and charts, 5 lb.; binoculars, 0.5 lb.; total, 40 lb.

[3] Two sledges with sail, mast, and canvas tanks, 55 lb.; one tent, 31.5 lb.; two cookstoves, 12 lb.; cooking utensils, 5 lb.; three 1-gal. cans (for carrying fuel), 2 lb.; two snow knives, 2 lb.; two snow shovels, 9 lb.; two saws, 2 lb.; one ice axe, 1.5 lb.; one sledge meter, 9 lb.; four pairs of skis, 44 lb.; four pairs of ski poles, 8 lb.; one pair of snow shoes, 8 lb.; one dozen orange flags, 1.75 lb.; alpine rope and safety belts, 14 lb.; sewing kit, 4 lb.; man harness, 3 lb.; medical kit, 2 lb.; miscellaneous spare parts, 5 lb.; total, 216 lb.

During the flight a strong southeast wind was encountered, making it necessary to run the engines at around 1600 r.p.m. when flying over the Ross Barrier. Over the plateau the wind was still fairly strong from the east-southeast, making it necessary to cruise at fairly high r.p.m.


SHOWING "CITY OF NEW YORK" AND FAIRCHILD PLANE ON FIRST FLIGHT
LITTLE AMERICA UNDER CONSTRUCTION
DOGS ARE STILL ESSENTIAL

The South Pole was reached around 1:14 a.m. Greenwich time, November 29, 1929. The course was then set for the Queen Maud depot at 1:25 a.m., and a landing made there at about 4:45 a.m. Taking off at 6:00 a.m., Little America was reached at about 10:10 a.m.

The average gasoline consumption per hour for the entire flight was 50.70 gal., and on the flight from Little America to the South Pole, thence to Queen Maud Depot, was 57 gal. per hour.

PLANES USED BY THE EXPEDITION

The planes that were used in the Antarctic were a Ford (trimotor), a Fairchild, and a Fokker (Super Universal).

The Ford plane, a model 4-A.T., was equipped with two Wright Whirlwind Model J-5 and one Wright Cyclone Model R-1750 engines. The total tank capacity was 740 gal. There were five tanks located in the wings, three of 130 gal. each and two of 110 gal. In the fuselage one tank of 130 gal. was hooked up to the center fuel tank with a hand pump located on the side of the left pilot seat. From the center tank an overflow line returned the surplus fuel to the fuselage tank. This tank was also equipped with a dump valve, in case of the necessity of lightening the plane. The five-wing tanks were connected to a collector placed on the front spar in the cabin. From here the fuel was distributed to the engines. The amount of fuel was measured by a glass-tube gage threaded into the collector tube.

The cabin trim and chairs were not installed. Glass windows on the side of the fuselage were replaced by celluloid. This made a saving of about 600 lb. in weight. In the rear part of the cabin floor a hole was provided for taking drift observations. The fuselage tank, an ordinary 130-gal. Ford wing tank, was placed on the left side of the fuselage on the floor behind the front spar. Just behind the rear spar on the left, a table for the navigator was arranged. This was made strong enough to stand on when sextant observations had to be taken through an opening provided for this purpose in the roof of the fuselage.

The skis used on the Ford plane were about 11 ft. long and 31 in. wide, made of laminated hickory riveted together with copper nails and with three brass runners about 7 in. wide. The front ends were bent up about 10 in. and the rear ones about $2^1/_2$ in., both ends being rounded. The skis were kept in nearly horizontal position to the line of flight with the help of rubber shock cords at the front and a check wire at the rear.

The Fairchild F.C.-2W2 was equipped with a Pratt & Whitney Wasp engine, Model A. In addition to the ordinary wing tanks, two extra tanks were placed outside in the wings. A 75-gal. auxiliary tank could be installed in the cabin when needed.

This plane was taken especially for mapping purposes. The landing gear was made specially for ski work. It is the author's opinion that a rigid landing

gear, with the shock-absorbing unit in the ski pedestal, is more advantageous than just using the ordinary wheel landing gear, when flying from rough and unprepared fields, as is generally the case when operating in the polar regions. It has the advantage that the treads of the skis are constant and there is no lateral movement of the skis due to travel of the struts containing shock units. Also the twisting forces frequently encountered when taxiing and turning are more evenly taken care of by the different landing-gear members. On previous trips made in the polar regions, trouble had been experienced from twisted fuselage fittings when turning with the ordinary type of landing gear.

The shock-absorbing units consisted of rubber shock cord wound around a stationary axle and a cradle sliding in vertical guides.

The Fokker Super Universal was equipped with a Pratt & Whitney Wasp engine, Model A. In addition to its ordinary tank capacity, two 90-gal. wing tanks, an extra 90-gal. tank was carried in the dome of the wing, as well as a 75-gal. tank in the fuselage when needed.

Both the Fairchild and the Fokker planes had openings in the roof and floor of the cabin for sextant and drift observations. All three planes were equipped with radio short- and long-wave transmitters and receivers. In addition, every plane on flights away from the base carried emergency radio sets for use in case of forced landings and the possibility of traveling back on foot.

Housing Planes for the Winter

As previously mentioned, the Fokker Super Universal blew away in a blizzard at the Rockefeller Mountains when a party was there surveying them during the first season of operating. The problem of housing the two remaining planes was solved as follows:

The Ford plane was partly assembled: center section put on the fuselage, motors hung on, and landing gear and skis attached. A hole about 8 ft. deep was then dug, large enough to give sufficient room in which to move around the plane, and an incline was made at the rear end of the hole and the plane stowed there. A wall of snow blocks was built around the hole up to the height of the center section. The rear part was filled in with snow, bamboo poles were laid from the top of the plane and over on the snow wall, thus making a framework; over this were stretched tarpaulins, which were weighted down on the walls with snow blocks. The Fairchild plane was equipped with folding wings. These were folded back alongside the fuselage and a snow wall made around a framework of bamboo poles laid across, and covered with tarpaulins weighted down with snowblocks. In this manner the planes were stored for the winter. It was found that flat roofs were more advantageous on storehouses and similar shelters than ordinary-shaped roofs as the wind kept the snow off them. It was possible to work with bare hands down in these places when a couple of blow torches were going full blast when the outside temperatures were ranging around 50 to 60 deg. fahr. below zero! The detail assembly, alterations of gasoline system, and checking and timing of engines were all done in this snow hangar.

The wing tips of the Ford were left on two sledges each and staked down well, and then snowed under. When spring came they were dug out, and of course were full of snow inside. They were then covered with tarpaulins, and five to six blow torches started up beneath them and the snow melted out. The wing tips were put on when the plane was still down in the snow hangar. When everything was ready, a 1:5 incline was dug in the front of the plane, the center engine started, and the plane taxied out of the hangar under its own power.

The oil tanks and oil lines on all three planes were lagged with asbestos and then covered outside with fabric and doped in order to reduce heat radiation from the oil. The oil sumps on the engines were also asbestos-covered. The intake manifolds on the outboard engines on the Ford also had to be lagged with asbestos. All engines were equipped with hot spots but not with preheaters, which latter would no doubt have been advantageous for such work.

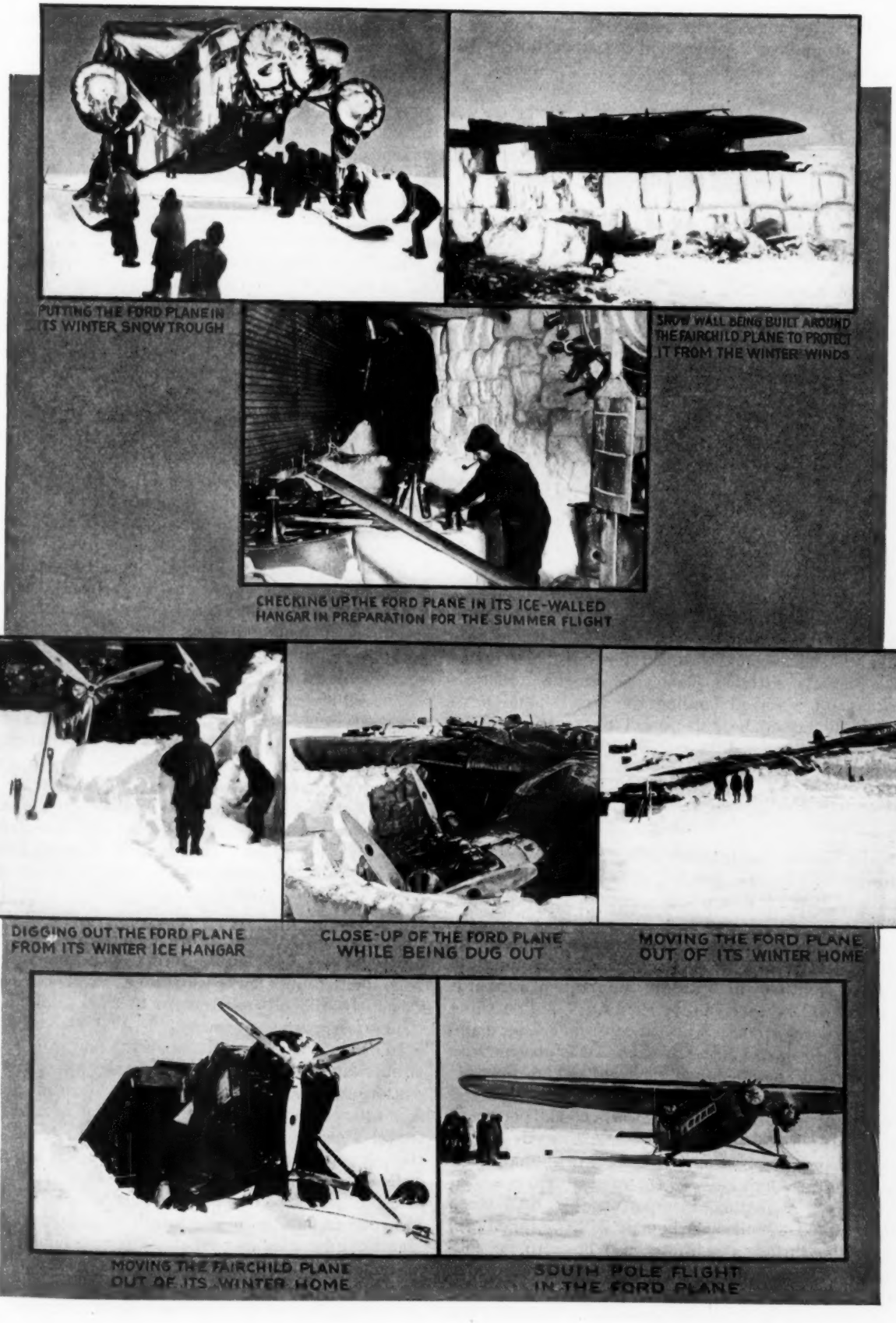
In heating the engines a canvas hood was made that covered the engine and the nose of the plane up to the cockpit or far back on the engine nacelle. The bottom of this cover was made into a funnel, to which a double ring 6 in. high and 15 in. outside diameter was added. To the bottom of this a cylinder 24 in. high and $9\frac{1}{2}$ in. in diameter, containing the blow torch, could be attached. A baffle plate was put on top of the blow torch in order to decrease the fire hazard. Nevertheless, these blow torches had always to be watched very carefully when applied to the engines.

The average time required to warm up a single-engined plane with a 400-hp. motor was about 45 min. in a temperature of from 20 to 30 deg. fahr. below zero. The trimotor usually took from one to one and a half hours to get warm.

The oil had to be heated separately. It is very important not to overheat the oil, otherwise its lubricating quality is reduced, and excessive carbonization around the oil strainers takes place, causing loss of oil and in some cases broken pump gears.

After the engines are stopped the oil has to be drained immediately, otherwise it is apt to congeal at once in the oil lines. It is important to have drains of large diameter for the oil.

After flight operations had ceased during 1930 and it was realized that it was not possible to get the machines back from the Antarctic on account of the late season and bad ice conditions, the two planes were taxied up on a hill due east of Little America, trenches 2 ft. deep dug for the skis, and the planes taxied in. Deadmen were put at the front, sides, and rear. The tail surfaces were taken off and put inside the cabin. The planes were faced east into the prevailing winds and the tail built up on empty gasoline drums, giving the


PUTTING THE FORD PLANE IN ITS WINTER SNOW TROUGH
SNOW WALL BEING BUILT AROUND THE FAIRCHILD PLANE TO PROTECT IT FROM THE WINTER WINDS
CHECKING UP THE FORD PLANE IN ITS ICE-WALLED HANGAR IN PREPARATION FOR THE SUMMER FLIGHT
DIGGING OUT THE FORD PLANE FROM ITS WINTER ICE HANGAR
CLOSE-UP OF THE FORD PLANE WHILE BEING DUG OUT
MOVING THE FORD PLANE OUT OF ITS WINTER HOME
MOVING THE FAIRCHILD PLANE OUT OF ITS WINTER HOME
SOUTH POLE FLIGHT IN THE FORD PLANE

wing a negative angle to the horizontal. A snow wall was built around the fuselages and the cabins filled with 5-gal. gasoline and oil cans to weight them down.

SPRING OR FALL THE BEST TIME FOR ANTARCTIC FLYING

During the stay at Little America, it was found that the best time of the year for flying is in the spring or fall. Winter of course is out of consideration on account of the darkness. During the early spring and late fall, when the water is frozen over the major part of the Ross Sea, the temperature is low, but more uniform, resulting in cold but clear weather.

When summer comes, with open water in the Ross Sea and temperatures above zero, much fog and many overcast days are experienced. In the latter part of December, January, and the beginning of February, hardly more than five to seven flying days a month can be counted on. For this reason it is the author's opinion that in the Antarctic it is necessary to stay through the winter and plan on doing the major part of the flying early in the spring.

As regards the type of plane suitable for the work of a polar expedition, it should have a large cabin, making it possible to load in a lot of bulky items such as sledges, tents, skis, food, etc. Also openings with sliding doors in floor and top of cabin for sextant and drift observations, openings in sides of fuselage for oblique photography, and easy communication between pilot's cockpit and cabin are essential. Radio sets should be so constructed that it will be possible to maintain connection with the plane set from the ground.

In case of a forced landing the crew should have supplies enough to be able to get either back to the base or to some meeting point, arranged previously, with possible relief parties.

PRECAUTIONS WHICH FUTURE PARTIES SHOULD OBSERVE

In the future, the landing of survey and geological parties, with supplies, out in the field will have to be considered when laying out a schedule for operations. A party out in the field would most likely keep the plane with them, but a serious problem confronting them would be that of securing the plane and preventing it from blowing away in the frequent blizzards which have to be taken into account. The first thing to be considered when landing away from the base and selecting a camp site is the relation of the obstructions in the terrain to the prevailing wind. The direction of the wind of any considerable strength can be determined from the furrows in the snow, called "sastrugi," which are parallel thereto. Chinooks seem to be frequent along the mountain range. Furthermore, the air is more turbulent close to the ranges than out over the barrier. A factor of importance is that when winds up to 60–80 miles per hour have to be taken into account the surface conditions also have to be considered. A place where it is possible to dig a trench into which the plane can be taxied and secured, facing into the prevailing wind, is preferable. Securing the plane with the tail in the wind makes it difficult to keep the control surfaces from bending and tearing loose. At the Rockefeller Mountains, where the surface consisted of blue ice covered with a layer of hard snow, after the wind reached a velocity of between 80 and 90 miles an hour the snow blew away in patches, which made securing difficult. A satisfactory way, according to the author's experience, is to dig a trench wide enough for the skis and from two to three feet deep according to the size of the plane, and taxi the plane into the trench.

The plane will then be stored with the tail high and the wings nearly parallel to the ground. The best type to use would be a low-wing monoplane; a snow wall could then be built around the wing and fuselage, thereby preventing the wind from getting any hold under the plane. Deadmen should be put in front and under each wing tip. Those in front should be placed about 20 to 30 ft. ahead and secured to the landing gear. For the wing tips the deadmen should be buried a little in front of the leading edge of the wing. All deadmen should be buried about 3 ft. deep and the snow packed hard on top. Special facilities should be provided for fastening securing lines at the top wing. The sledges or skis can be used as deadmen.

Air-cooled engines are the only ones to be considered when cold-weather operations away from the regular flying field are contemplated. With the new cowling rings now available it is possible to regulate the temperatures on the engines satisfactorily in nearly every conceivable case.

The single-engined plane is also to be preferred, since serviceing and handling are much easier when in the field, where the question of time and labor when getting a plane ready for flight is often very important. The cruising speed as a general rule is greater for a single-engined plane than for a multi-engined one.

Another essential feature to take into consideration when choosing planes for this kind of work is a low speed at take-off and landing. It is the author's belief that this should take precedence over higher cruising speeds.

Serviceability is also an important factor, since work on the planes and engines during operations has to be done for the most part at low temperatures, when it is extremely difficult and tedious to work around metal structures with bare hands.

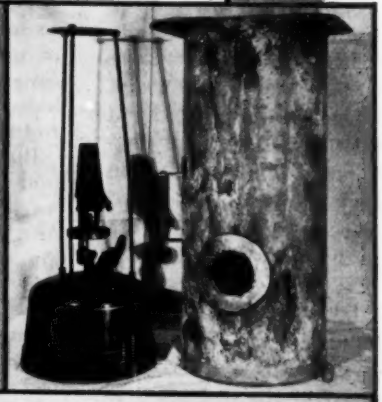
In order to transport the planes to and from the field of operation it is desirable to have the wings in several sections, especially when large planes are in question. A cantilever-monoplane one-piece wing is much more troublesome to handle, stow away, and transport to the place of operation than would be a wing that could be crated in three pieces and stowed away. It is also desirable to make long fuselages in several parts in order to cut down the length of the crates. The crates can be used to advantage as storehouses and as material for house building. The workshop at the flying field in Little America was made from the crate for the fuselage of the Fairchild plane.

TYPE OF HEATER USED FIRST YEAR

TYPE OF HEATER USED SECOND SEASON

REAR VIEW OF SECOND SEASON HEATER

BLOW TORCH AND HEATER



SKI EQUIPMENT FOR SNOW FLYING

FOKKER PLANE SECURED AT ROCKEFELLER MOUNTAINS PRIOR TO BEING WRECKED IN THE BLIZZARD

ADMIRAL BYRD READY FOR A SOJOURN TO THE POLE

WRECK OF FOKKER AFTER A BLIZZARD

Research in Industry

By C. F. HIRSHFELD,[1] DETROIT, MICH.

HAVE you ever wondered why the leaves of deciduous trees take on such wealths of color after the first frosts? Have you ever wondered why the evergreens behave differently? Have you ever wondered why fruits change color as they ripen? Have you ever wondered what makes your lungs draw in and force out gases so regularly? Have you ever wondered what makes the winds blow?

You are a fairly intelligent group of men. And yet, I shall venture to say that very few of you have ever wondered about such natural phenomena with which you have been acquainted since early youth. More than this, I am certain that still fewer have taken the trouble to go beyond the wondering stage and endeavor to discover the reasons. If some of you have had the reasons for the particular phenomena that I have mentioned forced upon you in botany or physiology or meterology, do not take credit for that fact; I could cite hundreds of other examples to convince you that, in general, most of you go through life without ever questioning the causes back of what you recognize as natural phenomena.

But, you need not feel put out about it. In this respect you are acting like the average human. You are, in general, satisfied to accept, without really understanding, all those things with which you are familiar. I am inclined to believe that this is a heritage from your animal ancestors, but of that I cannot be certain. At any rate, we need not now worry about the reason, we need only the fact.

Acceptance of the Familiar Without Understanding

Yet we are accustomed to say that we learn by experience. Well, in certain respects we do. When we are first learning to walk we discover by said experience that failure to maintain our balance results in a catastrophe, more or less unpleasant as determined by the extent of upholstering upon the part making violent contact. This unpleasant phenomenon undoubtedly spurs us on until we become sufficiently skilled in maintaining a precarious balance to enable us to avoid such unwelcome impacts upon our anatomical structure. But, look a little deeper. Is one of you consciously aware of the marvelously intricate interactions of your nerves, muscles, and other component parts which are used in walking? I think not! Truly, you have learned to walk by experience in walking, but have you really learned, in any basic sense, what walking is? You will surely admit that you have not.

Looking at this matter in an open-minded way, is it not true that when we say that we become familiar with a thing, and that when we say that we learn by experience, we should really be more correct, in most cases, in saying that familiarity and experience cause us to accept unquestioningly, and to overlook the necessity or desirability of digging beneath the surface appearance to determine the actual mechanism? I feel very certain that if you will give this matter serious thought, unbiased by previous understanding, tradition, or conviction, you will come to this conclusion. It makes us out a rather sorry lot, but such we are. Most of us do very little real thinking.

On the other side of the ledger, it is true that there appear always to have been exceptions to this general rule. There appear always to have been some humans who have felt the urge to delve beneath the easily acceptable and obvious and to offer explanations. The efforts of these men have always been limited by the methods and equipment available to them. At the start, they had nothing but what we may call their imaginations and certain embryonic reasoning powers. With such tools they first personified and then deified natural phenomena and natural forces. You are all more or less acquainted with the ancient religions, mythologies, philosophies, and folk tales that resulted. With such tools they produced a flat earth over which the sun traveled daily. With such tools they produced

AS ENGINEERS you have been taught the research method. You have been taught to marshal all available facts and to then make the best decision that you can in the light of those facts. And you have expected to spend your lives applying this method to the solution of certain industrial problems, such as design, fabrication, construction, sale, or even possibly management. You have, all unawares, planned to apply the research method to the component parts of industry.

But I feel very certain that some of you are going to find the world calling upon you to solve in an engineering way problems which are not of an engineering character. And this not because you are engineers but because you are trained in the research method; because you instinctively base opinion, decision, and action upon the best determination of facts at the time available. It is a glorious and a romantic task that those of you who will be so chosen have before you, and I not only hope but I feel certain that you will give as good an account of yourselves in this more advanced stage of human development as did your predecessors of other types in the stages in which they predominated.

C. F. HIRSHFELD.

---

[1] Chief, Research Department, Detroit Edison Company. Mem. A.S.M.E.

Presented at a meeting of the Philadelphia Section of the A.S.M.E., Philadelphia, Pa., February 24, 1931.

a limited earth over the edge of which one might drop to oblivion if sufficiently careless.

THE SCIENTIFIC METHOD—ITS INCEPTION—WHAT IT IS

Measured in terms of anthropological history, it took a very, very long time to rise above such simple methods. But finally there appeared men with a greater development of intellect which called for the development of better methods and better tools. As a result, their observations and their conclusions became different in character. No longer was it sufficient to imagine a system or an explanation. No longer was pure mental fiction acceptable at face value, at least to the informed few. Explanations and systems had to stand the test of more or less rigorous proof. And there gradually developed what we now call the Scientific Method. This did not happen quickly and finally. It was not as though a bird of strange character suddenly appeared upon the earth and then remained, known and familiar to all. This bird, if we may continue the figure of speech, arrived and departed a number of times, and on arrival did not always land in the same place. It alighted first here and then there, and was often absent for long periods. But finally there grew in the minds of a limited number of individuals an appreciation of this strange creature, and the scientific method was established. It became accepted by the few as the best available to man in the solution of natural phenomena, and its appreciation gradually spread to larger and larger numbers. Later man even seriously considered adapting the same method to the solution of other types of problem, such as sociological and economic. This latter movement has only just started, and it is almost too early to expect sweeping results from it.

It is now pertinent to ask just what is this scientific method? I do not want to lead you into a long abstract discussion of deductive versus inductive reasoning, and therefore I shall confine myself to another and simpler method of definition. Assume that we desire to find out about a certain phenomenon. We may speculate as to the various imaginable explanations. But so long as we confine ourselves to such speculation only, there will be, in general, a great number of such explanations and no means of deciding between them. Suppose now that we make our method more rigid. We analyze the possible explanations and we find that certain measurements that we might make should show that some are tenable and others untenable. When we make such measurements we narrow down the field. Finally, if we are sufficiently skilful in devising methods of measuring, we may eliminate all but one, so that we feel reasonably safe in assuming that that is the correct one. If we are still more skilful we may be able to reason that, if this is the correct explanation, some other phenomenon should be producible by certain methods of procedure. If we then succeed in producing this phenomenon in the predicted way, we feel still more certain that we have the correct explanation. It will be observed that this method of attack is a combination of imagination, intuition, and measurement. These ingredients may be scrambled in various ways, but so long as final dicta rest on experimental proof, that is, measurement, we are dealing with what we now regard as the scientific method.

I should like now to point out several facts before we form too high an estimate of the scientific method. First, it enables us only to say that under a given set of circumstances a certain thing happens in a certain way. It is true that if we are sufficiently skilful with mathematics we may be able to reason mathematically from this assemblage of facts to some other condition. But we never really know whether our mathematical reasoning is correct until we experiment under the new set of conditions. This is not the fault of mathematics—it reflects an unfortunate limitation of the human intellect.

Again, the scientifically derived explanation of today is not always the scientifically derived explanation of tomorrow. As we increase our general fund of knowledge and as we improve our tools of measurement, we frequently find it necessary to revise our earlier conclusions. This sometimes means that our earlier conclusions were incorrect; more often it means that they were incomplete or misinterpreted.

GENERALIZATION OF SCIENTIFIC KNOWLEDGE FAR FROM COMPLETE

Further, the greater part of our so-called scientific knowledge consists of a vast collection of uncoordinated facts or experiences. We have made very little progress toward complete generalization. To illustrate, we have a very complete mathematical treatment of what we call potential fields in the study of electricity and magnetism. By means of this treatment we can predict results under assumed conditions, and we find by experiment that our predictions are substantially correct. Now it happens that we can use the same mathematics in treating problems involving the flow of fluids, such as water in hydrodynamics and air in aerodynamics. But, with the limitations of our human intellects, we are forced to form entirely different pictures when we attempt to interpret the same mathematical forms in these radically different fields. One might say that we have generalized these problems mathematically but not physically.

And, finally, much of our scientific work consists only of the naming of certain things and the determination of certain mathematical relations between them. It is as though we discover that a certain man is named John and that he has a cousin James and that they live in the same house, but that we know nothing of John and James as men, whence they came, what and where their families are, what functions they serve in the social organism, etc. We frequently overlook this fact about scientific knowledge. We frequently fail to realize how far from basic it is.

Take, for example, the so-called force of gravity. You all know what it is in the sense that you know what it does and according to what laws it behaves. But not

one of you knows what it really is or why it does what it does. We frequently fool ourselves into believing that our scientific knowledge is much more general, much deeper, much more basic than it really is.

NATURE OF RESEARCH

Let us now come to the subject of this evening's discussion, namely, Research. Just what is it? The dictionary will tell you that it is an ordered search for truth, or will give you some other similar definition. There are obviously two essential parts to this definition: the means employed, namely, an ordered search, and the object sought, namely, the truth. From what I have already said to you, you will appreciate the fact that the ordered search must be by the scientific method if it is to amount to anything. And you will also realize that the truth cannot be more than the best approximation to the truth obtainable at the time, since what appears to be the truth today may not be regarded as the truth tomorrow. For these reasons I prefer to expand the dictionary definition somewhat and to define research as an orderly, scientifically conducted search for the nearest approximation to the absolute truth that is at the time discoverable or desired. The nearest possible approximation to the truth may not be desired in a given case; something much more approximate and much less costly may be sufficient for the purpose in view.

But research is only part of the subject assigned me this evening. I am also required to tell you of its application to industry. This immediately brings us face to face with a differentiation which is commonly made in the field of research. You will find that this field is generally divided into two parts designated respectively as pure research and applied research. The theory is that the former confines itself to uncovering the secrets of nature, that is, so-called scientific facts, and that the latter confines itself to the application of such discoveries for the benefit of humanity. The former has been called the raw material of industry, but it is really more than that, it is the raw material for at least the physical part of human existence.

RESEARCH IN INDUSTRY

One might jump to the conclusion that industry concerns itself only with applied research. In an ideal social organization this might be the case. But, as things are, it is very definitely not. The truth is that industry needs this particular raw material at an ever-increasing rate, and at a rate so great that it cannot wait for its production through the more or less haphazard operations of single or small groups of scientists following their individual bents, or through the comparatively restricted efforts of privately endowed foundations and Government departments. Industry is therefore forced to engage in pure research to a great extent in order to supply this raw material at the required rate. We thus have a rather unexpected situation; huge industries spending large sums annually on pure research which appears to hold no immediate prospect of being convertible into things salable and therefore into dollars. But you may be very certain that if experience did not show that the dollars were eventually procurable in sufficient quantities by virtue of such work, the work would very quickly cease.

Let us now consider industry for a minute. Most of you will immediately picture the recovery of raw materials, manufacturing, and transportation as the fields covered. In a strict sense industry also includes agriculture and all other human activities which are commonly engaged in for profit or as a means of making a living. However, I am going to confine myself to the narrower interpretation this evening, because I suspect that that was what those responsible for my subject really had in mind, and also because it gives me a sufficiently broad field to wander over.

The beginnings of many of our industrial processes are buried in antiquity; others are of recent date. In those cases in which the process is very old, we know nothing of its genesis. In our present conceit we attribute such processes to accident, as illustrated by the various stories about the discovery of glass, the discovery of earthenware, the discovery of iron, and so on. In the cases of more recent date we are frequently aware of the series of inventions which led up to the development that we now know. Irrespective of the beginnings, the fact is that we have at any given time in modern history a complex collection of industries carried on by methods very largely inherited from earlier generations.

If you will now think back to some of my earlier remarks about human characteristics, you will recognize the fact that such inherited methods and ideas are quite apt to be accepted unquestioningly and taken at face value. We are very apt to assume that that which has worked in the past must be correct and must work in the future. This is actually the assumption in the greater part of industry today. Knowledge has been passed down from father to son, from foreman to foreman, from superintendent to superintendent, from executive to executive, from banker to banker. And in most cases they have been satisfied to continue with this inherited knowledge, correctly or incorrectly interpreted.

But, just as happened with respect to the interpretation of natural phenomena, there have been here and there individuals who have questioned tradition and other forms of inherited lore, who have thought it best to strike out for themselves and to see what they could find. These were the men who in a small and embryonic way introduced research to industry. They were not satisfied with living and working along conventional lines, they wanted to blaze new trails. They automatically questioned the methods of yore, taking the stand that every single step in a process must justify itself as of today and not on the basis of genealogical respectability.

And thus there has gradually come a growing appreciation of the possibilities latent in the application of scientific methods to industry, both for the purpose of

checking tradition and for the purpose of improving upon the results obtainable by traditional methods. This is bringing about a very great, although almost imperceptible, change in the entire industrial situation. Not so very long ago whole industries were dependent upon the carefully guarded knowledge locked up in one or a few human brains. Now we find the secrets of these industries laid bare in the laboratory so that any individual of reasonable intelligence can acquire them and become expert in their use. Truly have basic industrial conditions changed in this respect.

This is not all. Once having applied the searchlight of research to industrial problems, it becomes evident that this tool is capable of showing the way for ever-increasing improvement. And, under the stress of competition, you may expect more and more industries to avail themselves of the potentialities of this new tool. It is almost within the bounds of truth to say that industrial research has now become the fashion. To be sure, it is not yet universal; certain leaders of fashion point the way in all human endeavors, and then the mob follows if it can afford to. In this case it will have to be able to afford, because along that route, and along that route only, lies survival.

RESEARCH APPLICABLE TO ANY OF THE VARIOUS ACTIVITIES FORMING A PART OF INDUSTRY

I should like now to say a few words about industrial research in a more specific way. One is apt to obtain the impression that it applies only to such things as chemical processes, metallurgy, the cutting of metals, the heat treatment of materials, and other similar matters specifically associated with chemical and physical sides of manufacturing processes. This is far from a correct view. The research method is, after all, nothing but the conduct of an orderly search for facts, and it is applicable in any of the various activities associated with industry or forming a part thereof. Thus it will frequently develop that research applied to the accounting practices of a business produces far more immediate and valuable results than does research applied to the production process itself. Or, in another case, research applied to the personnel problems may be more profitable than in any other branch of the work. Such ideas may be new to you; they are to many. But I cannot too strongly stress the fact that research is not essentially and solely a laboratory process applicable only to inert materials. It is equally applicable to human beings and to all of their activities. And, incidentally, we should have a lot less buncombe in politics and many other forms of human activity if we could only act upon the results of an orderly search for truth instead of taking action on the basis of half-baked and politically or sentimentally colored statements that are now accepted in lieu thereof.

But I digress; we are supposed to confine our attention to research in industry. I have just endeavored to show you how it serves to cut loose the shackles of tradition, to free us from slavery to inheritance. I have endeavored to show you that it is applicable to all sorts of industrial enterprise and to all branches thereof. I should like now to say something about its mechanism, or perhaps I should say, the mechanism of its application.

We instinctively associate research with scientists. And therefore when we consider the introduction of research into industry we automatically consider that it is to be effected by grafting, in some way, one or more scientists upon an unregenerate industrial undertaking. This is what we most frequently do when we install a research engineer or a chief of research or a research department. Now it is true that certain problems can be solved in this way and that much improvement can be effected if personnel and methods are correctly chosen. But the maximum of results cannot thus be obtained.

RESEARCH, TO BE TRULY EFFECTIVE, MUST EXTEND THROUGHOUT AN ORGANIZATION

Research, to be truly effective in industry, must be common property, it must be the common method throughout the organization. Each foreman and each superintendent and so on up to the top of the ladder must be insistent upon operation on the basis of determined fact as against opinion, belief, tradition, or what not. Each of these individuals must be made a living question mark, and this requires considerable rebuilding in some cases. Each must be forever asking himself, "Why do we do this in this way? Is there any better way? Am I merely resting on opinion, or have I actually proved this matter?" Each must instill into his subordinates the never-ending quest for fact. It amounts to the production and maintenance of a certain mental attitude throughout the organization.

You recognize that I am stripping much of the mystery and glamour from industrial research. I do it intentionally. I do not want it to appear a mysterious, abstruse, and carefully guarded secret of the few; I want you to recognize it as the hard, sharable, common-sense thing that it is. If you were contemplating a trip to Europe and were a normally sensible human being you would not simply start for somewhere, hoping to land eventually in Europe. Nor would you feel that, because one of your friends had eventually landed in Europe by going from Philadelphia to San Francisco, you should also go to San Francisco as a first step in your progress to Europe. No, you would make inquiry and determine in advance the facts with respect to available routes, sailing dates, costs, clothing, and other equipment required, and so on. Then on the basis of such facts you would plan your European trip to such degree of refinement of detail as you desired. Is it not merely common sense to base industrial activities upon a similar determination of applicable facts instead of just blundering ahead as some one else blundered before you, until a smarter man either drives you to the wall or forces better methods upon you? Now that we have a common-sense method available for guiding our industrial endeavors, it is but common sense that we should use it. But remember, it cannot be used ef-

fectively if used only as the weapon of a specialist; it is necessary to train all hands in its use; that is, in the mental attitude that begets operation on the basis of fact.

And, even though research be but the application of common sense, you will find plenty of romance in it when viewed broadly. Look back over the progress we have made since we have tried, even in a small way, to base our actions on predetermined facts. Look particularly at the industries that have gone farthest in that direction, whether research has been directed to production, to personnel control, to advertising, to marketing, or what not. See how rapidly they are rearing their shoulders above the common herd. And, what is far more important, see how the people dependent on them prosper. You may first see only worldly prosperity—greater earnings and greater ease. In spite of all historical lore and proverbs to the contrary, I am firmly convinced that any worth-while and lasting social improvement of a major sort must rest upon the foundation of a reasonably prosperous and contented multitude. And while this cannot be achieved completely through research in industry, this modern tool is the best we have to hand, and may be expected to carry us a long way in that direction.

As engineers you have been taught the research method, whether you appreciated it at the time or not. You have been taught to marshal all available facts and to then make the best decision that you can in the light of those facts. You are part and parcel of a large group of similarly trained individuals, all known as engineers. And you have expected to spend your lives applying this method to the solution of certain industrial problems, such as design, fabrication, construction, sale, or even possibly management. You have, all unawares, planned to apply the research method to the component parts of industry.

But, gentlemen, unless I am greatly mistaken, at least some of you are not going to be permitted to spend your lives in any such interesting but, after all, narrow endeavors. The world at large is beginning to appreciate the virtue of basing action on facts, and not on the rather tenuous and intangible things that have so often underlaid momentous decisions and actions in the past. And when the world at large once makes up its mind to adopt new methods it does not ask what you intended doing with yourself; if you are fit it forces you to serve as it may require. And so I feel very certain that some of the younger of you, and possibly many, are going to find the world calling upon you to solve in an engineering way problems which are not of an engineering character. And this not because you are engineers but because you are trained in the research method; because you instinctively base opinion, decision, and action upon the best determination of facts at the time available. It is a glorious and a romantic task that those of you who will be so chosen have before you, and I not only hope but I feel certain that you will give as good an account of yourselves in this more advanced stage of human development as did your predecessors of other types in the stages in which they predominated.

Do not misunderstand. I am predicting neither Utopia nor the Millenium. Being the humans that we are, we are going to continue to blunder along in truly human fashion, rising from stage to stage over the accomplishments, the heartbreaks, and the mistakes of the stages that preceded. Suffice it that we do rise from stage to stage. And it is my firm belief that we shall so rise to the extent that we extend the research method from its cradle in the scientific laboratory through its later field of growth in industry to the much larger and much more worth-while field of human relations, or, let us say, the social structure.

Scale-Model Testing

TO ONE who has been engaged in experimental work in engineering for the last 40 years, one of the most striking developments which has taken place has been the increase in the application of the method of scale-model testing to the solution of engineering problems. The greater part of this development is due to the growth since 1910 of small-scale testing in aeronautical research, owing to the cost and risk of full-scale work; but, apart from this, the number of problems of a general engineering character for which a solution has been sought from a scale-model test has been considerable in recent years. Scale-model testing is not, of course, a comparatively modern kind of test; in fact, Newton showed that two systems of particles, if started similarly, will continue to move in a similar manner if the acceleration of each system is proportional to the product of the velocity and a linear dimension of the system, say, the diameter of a particle. This theory was extended by Stokes in 1850, and again by Helmholtz in 1873.

The first, and perhaps the most important, of all the practical applications of the method was that of William Froude in the development of experimental water tanks for the measurement of the resistance of ship models, and the prediction, from the results, of the resistance of ships. The method was also applied to the engineering problem of the design of notches and weirs, to give a constant coefficient of discharge, by James Thomson in 1876. It is to Osborne Reynolds that we owe some of the most fruitful applications of the method to engineering problems. Among these may be mentioned: (1) The experimental demonstration of the conditions of similarity of flow of water in parallel channels (1888); (2) the theory of the sand blast, in which he showed that the stresses produced by the impact were independent of the actual size of the grains; and (3) the law of comparison in the formation of sand banks in tidal rivers and estuaries.—Sir Thomas E. Stanton in the 37th James Forrest lecture, on Engineering Research, delivered before the Institution of Civil Engineers; abstracted in *Engineering*, May 8, 1931, p. 602.

Engineering in Its Relation to the Interstate Commerce Commission

Creation, Organization, and Duties of the Commission—Work of Its Various Bureaus, Including Services of Engineers in Valuation, Analysis of Expenditures for Equipment, Maintenance, and Extensions; Examination of Specifications for Locomotives, Safety Devices, Etc.; Determination of Suitability of Containers for Transportation of Explosives, Etc.

By FRANK McMANAMY,[1] WASHINGTON, D. C.

YOUR Chairman has asked me to talk on the subject of "Engineering in Its Relation to the Interstate Commerce Commission." It would be difficult clearly to describe or understand this particular feature of our work without first giving a general outline of the reasons for the creation of the Commission and the work which is assigned to it by law.

Authority to regulate interstate commerce rests upon paragraph 3 of section 8 of the Constitution, which provides that Congress shall have power "to regulate commerce with foreign nations and among the several States and with the Indian Tribes." It has been said that no equal number of words in any other paragraph or section of the Constitution have formed the basis for so great an amount of important legislation as have these, and none have had greater influence in shaping the destiny of the American people.

The commerce clause of the Constitution was written and adopted when our population was only 3,000,000 and our only vehicles were boat and wagon, yet that clause has remained unamended for more than 140 years and has been applied to numerous forms of transportation not even dreamed of at that time, and it still admirably serves the needs of a nation of more than 120,000,000 people.

The authors of the commerce clause, however, were not wholly without experience as to its need. Fiske tells us that both before and immediately following the Revolution the various colonies or states were exceedingly active in making commercial war upon one another. With no central authority there was and could be no uniformity in import or export duties or in the inspection laws. Those having ports sought to magnify them and monopolize both domestic and foreign commerce. Virginia sought to keep her tobacco at home by her export duties and inspection laws. Maryland, by the same means, sought to do the same with regard to her potash. Massachusetts prohibited the exportation of grain and unmanufactured calfskins, and imposed a heavy inspection tax on exports to other states on tobacco, butter, and other products. North Carolina laid an embargo on the exportation to other states of corn, wheat, flour, beef, and bacon. New York through import duties excluded butter, milk, and other dairy products from New Jersey and firewood from Connecticut. The need, therefore, at that early date for control by some central authority of interstate and foreign commerce was very apparent.

For many years after the adoption of the Constitution, Congress under the commerce clause exercised its authority in enacting laws relating to commerce by water, and in the aid of navigation made appropriations for canals and the improvement of rivers and harbors. With the coming of the railroads in about 1830, a new factor was injected into the situation. The need for additional transportation facilities for the development of a vast new country caused the people and Congress to aid in every possible way the development and extension of the new method of transportation, and for almost 50 years comparatively little was done toward its regulation. With no control, state or Federal, many abuses arose, and the growth of the railroads was accompanied by inflation, speculation, and exploitation. There were discriminations and rebates, and through the enjoyment of special privileges individuals and communities throve at the expense of others. The situation became so aggravated in the late seventies that midwestern states such as Illinois, Iowa, and Wisconsin passed what were termed "granger" laws, establishing either direct or through state boards freight rates, particularly upon agricultural products. The rail carriers promptly contested the constitutionality of these state laws in the courts. The Supreme Court of the United States, however, decided that a state had authority to fix its intrastate rates, and many states followed the example of the granger states. With no regulation of interstate rates much confusion and dissatisfaction arose, and the demand for Federal regulation grew until in 1887 Congress responded by the enactment of the act to regulate commerce which, like the commerce clause of the Constitution, was essential to protect the public welfare. This act created the Interstate Commerce Commission and provided the machinery for its operation. The authority of the Commission was from time to time broadened by

[1] Commissioner, Interstate Commerce Commission.

Presented at a meeting of the Washington Section of the A.S.M.E., Washington, D. C., January 22, 1931.

fectively if used only as the weapon of a specialist; it is necessary to train all hands in its use; that is, in the mental attitude that begets operation on the basis of fact.

And, even though research be but the application of common sense, you will find plenty of romance in it when viewed broadly. Look back over the progress we have made since we have tried, even in a small way, to base our actions on predetermined facts. Look particularly at the industries that have gone farthest in that direction, whether research has been directed to production, to personnel control, to advertising, to marketing, or what not. See how rapidly they are rearing their shoulders above the common herd. And, what is far more important, see how the people dependent on them prosper. You may first see only worldly prosperity—greater earnings and greater ease. In spite of all historical lore and proverbs to the contrary, I am firmly convinced that any worth-while and lasting social improvement of a major sort must rest upon the foundation of a reasonably prosperous and contented multitude. And while this cannot be achieved completely through research in industry, this modern tool is the best we have to hand, and may be expected to carry us a long way in that direction.

As engineers you have been taught the research method, whether you appreciated it at the time or not. You have been taught to marshal all available facts and to then make the best decision that you can in the light of those facts. You are part and parcel of a large group of similarly trained individuals, all known as engineers. And you have expected to spend your lives applying this method to the solution of certain industrial problems, such as design, fabrication, construction, sale, or even possibly management. You have, all unawares, planned to apply the research method to the component parts of industry.

But, gentlemen, unless I am greatly mistaken, at least some of you are not going to be permitted to spend your lives in any such interesting but, after all, narrow endeavors. The world at large is beginning to appreciate the virtue of basing action on facts, and not on the rather tenuous and intangible things that have so often underlaid momentous decisions and actions in the past. And when the world at large once makes up its mind to adopt new methods it does not ask what you intended doing with yourself; if you are fit it forces you to serve as it may require. And so I feel very certain that some of the younger of you, and possibly many, are going to find the world calling upon you to solve in an engineering way problems which are not of an engineering character. And this not because you are engineers but because you are trained in the research method; because you instinctively base opinion, decision, and action upon the best determination of facts at the time available. It is a glorious and a romantic task that those of you who will be so chosen have before you, and I not only hope but I feel certain that you will give as good an account of yourselves in this more advanced stage of human development as did your predecessors of other types in the stages in which they predominated.

Do not misunderstand. I am predicting neither Utopia nor the Millenium. Being the humans that we are, we are going to continue to blunder along in truly human fashion, rising from stage to stage over the accomplishments, the heartbreaks, and the mistakes of the stages that preceded. Suffice it that we do rise from stage to stage. And it is my firm belief that we shall so rise to the extent that we extend the research method from its cradle in the scientific laboratory through its later field of growth in industry to the much larger and much more worth-while field of human relations, or, let us say, the social structure.

Scale-Model Testing

TO ONE who has been engaged in experimental work in engineering for the last 40 years, one of the most striking developments which has taken place has been the increase in the application of the method of scale-model testing to the solution of engineering problems. The greater part of this development is due to the growth since 1910 of small-scale testing in aeronautical research, owing to the cost and risk of full-scale work; but, apart from this, the number of problems of a general engineering character for which a solution has been sought from a scale-model test has been considerable in recent years. Scale-model testing is not, of course, a comparatively modern kind of test; in fact, Newton showed that two systems of particles, if started similarly, will continue to move in a similar manner if the acceleration of each system is proportional to the product of the velocity and a linear dimension of the system, say, the diameter of a particle. This theory was extended by Stokes in 1850, and again by Helmholtz in 1873.

The first, and perhaps the most important, of all the practical applications of the method was that of William Froude in the development of experimental water tanks for the measurement of the resistance of ship models, and the prediction, from the results, of the resistance of ships. The method was also applied to the engineering problem of the design of notches and weirs, to give a constant coefficient of discharge, by James Thomson in 1876. It is to Osborne Reynolds that we owe some of the most fruitful applications of the method to engineering problems. Among these may be mentioned: (1) The experimental demonstration of the conditions of similarity of flow of water in parallel channels (1888); (2) the theory of the sand blast, in which he showed that the stresses produced by the impact were independent of the actual size of the grains; and (3) the law of comparison in the formation of sand banks in tidal rivers and estuaries.—Sir Thomas E. Stanton in the 37th James Forrest lecture, on Engineering Research, delivered before the Institution of Civil Engineers; abstracted in *Engineering*, May 8, 1931, p. 602.

Engineering in Its Relation to the Interstate Commerce Commission

Creation, Organization, and Duties of the Commission—Work of Its Various Bureaus, Including Services of Engineers in Valuation, Analysis of Expenditures for Equipment, Maintenance, and Extensions; Examination of Specifications for Locomotives, Safety Devices, Etc.; Determination of Suitability of Containers for Transportation of Explosives, Etc.

By FRANK McMANAMY,[1] WASHINGTON, D. C.

YOUR Chairman has asked me to talk on the subject of "Engineering in Its Relation to the Interstate Commerce Commission." It would be difficult clearly to describe or understand this particular feature of our work without first giving a general outline of the reasons for the creation of the Commission and the work which is assigned to it by law.

Authority to regulate interstate commerce rests upon paragraph 3 of section 8 of the Constitution, which provides that Congress shall have power "to regulate commerce with foreign nations and among the several States and with the Indian Tribes." It has been said that no equal number of words in any other paragraph or section of the Constitution have formed the basis for so great an amount of important legislation as have these, and none have had greater influence in shaping the destiny of the American people.

The commerce clause of the Constitution was written and adopted when our population was only 3,000,000 and our only vehicles were boat and wagon, yet that clause has remained unamended for more than 140 years and has been applied to numerous forms of transportation not even dreamed of at that time, and it still admirably serves the needs of a nation of more than 120,000,000 people.

The authors of the commerce clause, however, were not wholly without experience as to its need. Fiske tells us that both before and immediately following the Revolution the various colonies or states were exceedingly active in making commercial war upon one another. With no central authority there was and could be no uniformity in import or export duties or in the inspection laws. Those having ports sought to magnify them and monopolize both domestic and foreign commerce. Virginia sought to keep her tobacco at home by her export duties and inspection laws. Maryland, by the same means, sought to do the same with regard to her potash. Massachusetts prohibited the exportation of grain and unmanufactured calfskins, and imposed a heavy inspection tax on exports to other states on tobacco, butter, and other products. North Carolina laid an embargo on the exportation to other states of corn, wheat, flour, beef, and bacon. New York through import duties excluded butter, milk, and other dairy products from New Jersey and firewood from Connecticut. The need, therefore, at that early date for control by some central authority of interstate and foreign commerce was very apparent.

For many years after the adoption of the Constitution, Congress under the commerce clause exercised its authority in enacting laws relating to commerce by water, and in the aid of navigation made appropriations for canals and the improvement of rivers and harbors. With the coming of the railroads in about 1830, a new factor was injected into the situation. The need for additional transportation facilities for the development of a vast new country caused the people and Congress to aid in every possible way the development and extension of the new method of transportation, and for almost 50 years comparatively little was done toward its regulation. With no control, state or Federal, many abuses arose, and the growth of the railroads was accompanied by inflation, speculation, and exploitation. There were discriminations and rebates, and through the enjoyment of special privileges individuals and communities throve at the expense of others. The situation became so aggravated in the late seventies that midwestern states such as Illinois, Iowa, and Wisconsin passed what were termed "granger" laws, establishing either direct or through state boards freight rates, particularly upon agricultural products. The rail carriers promptly contested the constitutionality of these state laws in the courts. The Supreme Court of the United States, however, decided that a state had authority to fix its intrastate rates, and many states followed the example of the granger states. With no regulation of interstate rates much confusion and dissatisfaction arose, and the demand for Federal regulation grew until in 1887 Congress responded by the enactment of the act to regulate commerce which, like the commerce clause of the Constitution, was essential to protect the public welfare. This act created the Interstate Commerce Commission and provided the machinery for its operation. The authority of the Commission was from time to time broadened by

[1] Commissioner, Interstate Commerce Commission.

Presented at a meeting of the Washington Section of the A.S.M.E., Washington, D. C., January 22, 1931.

numerous other acts of Congress, which, however, need not be discussed here.

The railroads regulated by the various acts now operate 249,432 miles of road, which comprise 429,054 miles of track, 63,082 locomotives, 2,323,980 freight cars, and 53,838 passenger-train cars.

In 1929 the railway operating revenues amounted to $6,373,003,832. This averages over $50 per capita for every man, woman, and child in the United States. The transportation of freight has amounted to about 4000 net ton-miles per year per person. In other words, for every person in the United States approximately 220 pounds of freight is transported each day in the year a distance of 100 miles. Not only industry but the health and general welfare of the people are dependent upon the proper functioning of these transportation facilities.

ORGANIZATION AND WORK OF THE COMMISSION

The Interstate Commerce Commission is the oldest of the Federal regulatory commissions. It is an independent establishment. That is, it is not one of the executive departments of the Government nor is it subordinate to any such department. Initially it reported to the Secretary of the Interior, but almost immediately it was directed to report directly to Congress. In theory it is an arm of Congress appointed to carry out in detail the general policies laid down in the act which it administers. The Commission was created because it was believed that Congress could not undertake to handle directly all of the technical details which must be considered in connection with the regulation of so vast an industry as transportation.

Originally the Commission was a rate regulatory body only, but other functions of regulation have been assigned from time to time by legislative enactment. In the final analysis the work as a whole is designed to insure that in the world of transportation there shall be fair play, just equality of opportunity between shippers, commodities, and localities, and that there be maintained an efficiently operated system of transportation that is adequate in service and as safe as the state of the art permits.

The staff of the Commission is divided into the following bureaus, the title of each indicating in a measure the character of its work: Accounts, Finance, Formal Cases, Informal Cases, Inquiry, Law, Locomotive Inspection, Safety, Service, Statistics, Traffic, and Valuation.

WORK OF THE VARIOUS BUREAUS, INCLUDING DESCRIPTION OF ENGINEERING SERVICES IN CONNECTION THEREWITH

Some of the bureaus are not concerned with engineering matters except only in such cases as may require consultation or joint action on the part of two or more; however, on account of their interrelation to the whole a short statement of the major work of these will be included, together with more extended comment on the work of the bureaus where engineering is directly involved. I shall make no attempt to differentiate between the branches of engineering as the nature of the service will be apparent from the descriptions of the various activities.

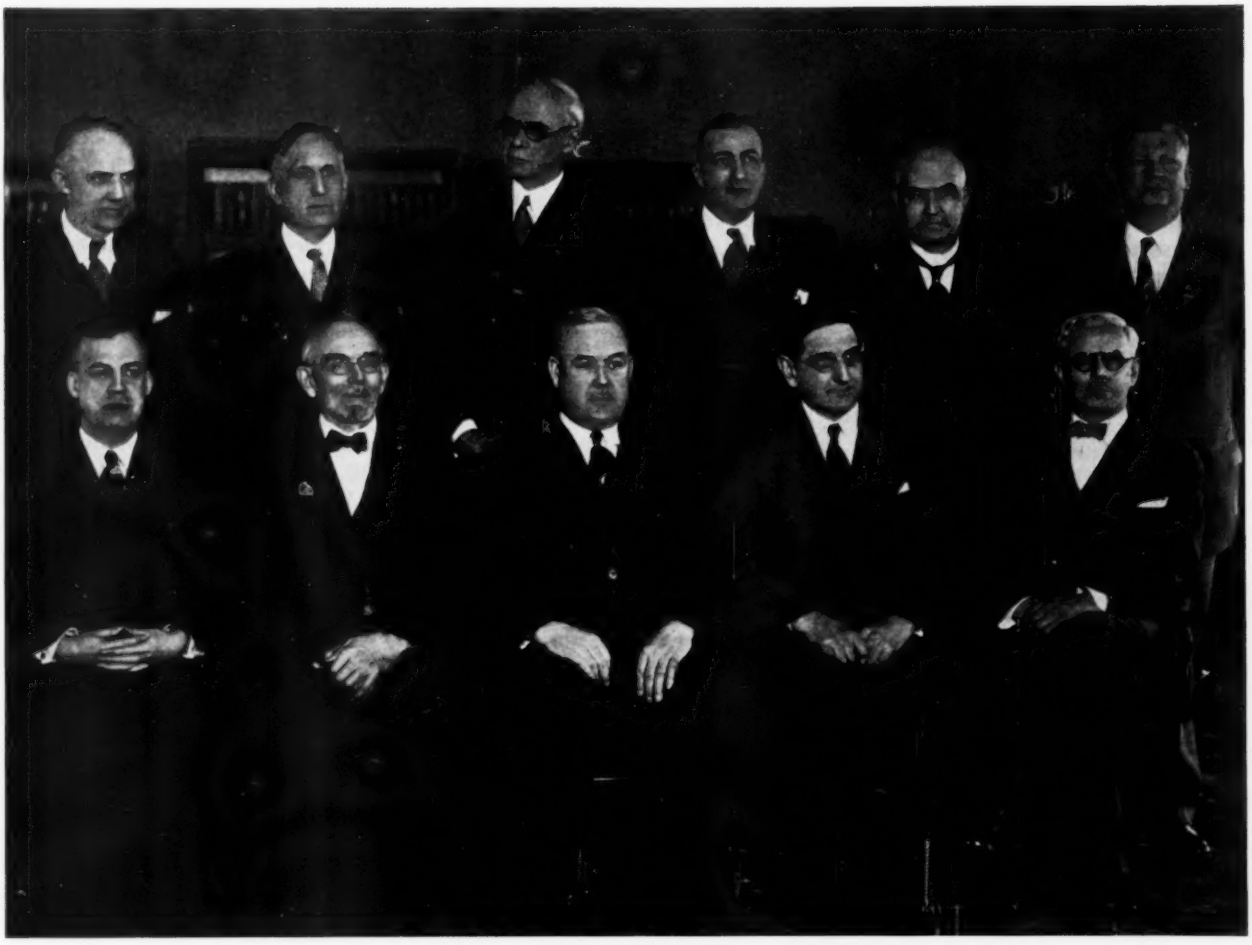
ACCOUNTS

Since 1907 the railroads have kept their accounts in conformity with rules prescribed by the Commission through its Bureau of Accounts. Prior to that time each carrier kept its books in its own way. There was no uniformity of treatment as between railroads or between different periods on the same railroad, therefore results were not comparable. To be of value figures must be comparable and the basis must be certain, hence the necessity for uniformity. The Bureau of Accounts through a corps of examiners conducts examinations of accounts of the carriers both for the purpose of seeing that the requirements are observed and to secure the data required to determine the necessity of recapture by the Government of excess earnings under section 15a of the Transportation Act. The bureau is also considering the question of depreciation charges which the law now requires to be set up by classes of physical property of common carriers subject to the act, which of course involves difficult engineering problems.

FINANCE

This bureau came into existence in May, 1920. Sections of administration, law, statistics, accounting, and of engineering were created under the immediate supervision of assistant directors to perform certain duties incidental to the administration of the provisions of the Transportation Act relating to construction, extension, and abandonment of lines of railroad, acquisition of control, issuance of securities, consolidation, recovery of excess earnings, interlocking directorates, loans to carriers, and the administration of the revolving fund of $300,000,000 which was provided for loans to carriers during the transition period immediately following the termination of Federal control. The loans applied for were so much in excess of the fund provided that this section was amended to limit the loans to certain purposes, namely, maturing indebtedness, the provision of equipment, and other additions and betterments. The engineers of the bureau were required to analyze each application for a loan to determine if the program of the applicant included other purposes than those prescribed by the law; to determine from the carrier's past and present record the probability of its ability to repay the loan when due; to recommend the amount and things for which a loan might be made; and, finally, after a loan was made, to require reports from the carrier of the use of the proceeds until the entire amount had been shown as used for the purposes specified.

Each carrier that had been under Federal control, and that accepted certain provisions, was guaranteed an income for the six months immediately following the termination of Federal control equal to its income



THE INTERSTATE COMMERCE COMMISSION

Standing, left to right: William E. Lee, Claude R. Porter, Thomas F. Woodlock, Ezra Brainerd, Jr., Patrick J. Farrell and Hugh M. Tate.
Seated, left to right: Joseph B. Eastman, Balthasar H. Meyer, Frank McManamy, *Chairman*, Clyde B. Aitchison, Ernest I. Lewis.

during the average six months of the test period, which period was the three years ending June 30, 1917. The guaranteed income was the said test-period income adjusted for differences in prices of materials and wages of labor and for differences in the amount of property maintained and the intensity of use to which the property was put as between the test and the guaranty periods, and rested on the proper adjustment of expenditures for maintenance. In the administration of this section engineers of the bureau were called on to analyze and consider all of the various methods proposed for determining factors representing the increase in prices of materials and wages of labor, and for determining the differences in the amount and use of property as between the test and guaranty periods; to determine the merit of the different proposals, and to recommend to the Commission methods for making the necessary adjustments.

After announcement of the Commission's decision in certain controversial matters involved in these determinations, engineers of the bureau were required to consider and analyze the return of each carrier and to determine the adjustments which should be made in the maintenance charges for differences in amount and use of property, and, together with the accountants of the bureau, were required to determine and recommend to the Commission the proper factors representing the general increase in prices of materials and wages of labor as between the test and guaranty periods.

In connection with the issuance of certificates of public convenience and necessity for the extension of present lines of railroad or operation, or for the construction of new lines or for the abandonment of existing lines of railroad or operation, the engineers of the bureau prepared the questionnaire which the applicants must answer as information, and are called upon to consider the practical and technical phases of the proposals, including matters which relate to the location, construction, and equipment of the new lines, their cost, and to determine from past and present conditions and future indications the economic prospects of the proposal. Engineers at times write proposed and final reports in connection with convenience and necessity matters, and on occasion hold hearings in these cases, particularly where the decision may

turn on the economics of railway location and operation.

Similar investigations by engineers are made in connection with applications concerning acquisition of control and consolidations.

Section 20a of the Transportation Act gives the Commission regulatory powers over the issuance by the railroads of securities. Since the effective date of this section no carrier has been able lawfully to issue any share of capital stock or any bond or other evidence of interest in or indebtedness of the carrier or assume any obligation or liability as lessor, lessee, grantor, indorser, surety, or otherwise, in respect of securities of any other person, natural or artificial, unless and until, and then only to the extent that, the Commission might authorize. Engineers of the bureau gave substantial aid in determining the information required to be furnished by the carriers with applications under this section.

If the application of a carrier for authority to issue securities rests upon accomplished expenditures, the applicant is required to submit with its application a copy of all completion reports for projects included in the application. If authority is sought to issue securities which will rest upon future capital expenditures, the carrier is required to submit with its application a copy of each authority for expenditure for the projects included. Engineers consider and analyze these data in order to inform the Commission whether or not it may make the finding required by Section 20a, that the issue (*a*) is for some lawful object within the carrier's corporate purposes, and compatible with the public interest, which is necessary or appropriate for or consistent with the proper performance by the carrier of service to the public as a common carrier, and which will not impair its ability to perform that service; and (*b*) is reasonably necessary and appropriate for such purpose. Where the issue rests upon future expenditures, reports are required from the carrier showing the disposition of proceeds from the sale of the securities until it is shown that these proceeds have been expended for the purposes set forth in the application. In the consideration of applications under this section it is necessary that engineers determine whether or not the expenditures, offered in support of the securities desired to be issued, are proper capital charges, and whether or not the unit prices are reasonable for the work done or to be done.

Formal Cases

The Bureau of Formal Cases deals with matters relating to rates and charges. It consists of attorney-examiners with the necessary office force. These attorney-examiners hold hearings, take testimony, analyze the records, and prepare proposed reports which form the basis for argument before the Commission or a division thereof. Some idea of the scope of this work may be obtained from the fact that during the past year 1419 formal proceedings were instituted and 1547 were disposed of. In connection with the hearing and disposition of these cases 219,519 pages of testimony were taken and analyzed, which is more than 700 pages for each working day. The opinions in the cases decided during this period aggregate more than 11,000 pages.

Informal Cases

Informal cases are complaints which by agreement of the parties are determined without formal hearing. These cases usually arise by letter of complaint from interested parties. The matter is handled by correspondence or by conference, and if a satisfactory understanding can be reached the Commission expresses its opinion by letter to the parties. By pursuing this method of handling complaints justice is done as between the parties, and it results in a tremendous saving in time and money by the railroads, the shippers or travelers, and the Commission. During the past year there were received 6651 informal complaints and 11,568 special docket applications for authority to refund amounts collected admitted to be unreasonable, and 10,658 orders authorizing refund were entered. Each of these cases was a potential formal complaint which was handled in this informal manner in the interest of economy and expedition.

Inquiry

This bureau deals with violations of the Interstate Commerce Act and related acts, with the exception of the acts to promote safety of employees and travelers on railroads, which latter are administered by the Bureau of Locomotive Inspection and the Bureau of Safety.

Law

The chief law officer of the Commission is the chief counsel, who is head of the Bureau of Law. He is aided by two assistant counsel and one attorney, with a small force of office assistants. Besides advising as to questions of law referred to him and keeping abreast of the progress of legislation and judicial decisions, he represents the Commission in cases in the Federal courts which involve orders or functions of the Commission.

Locomotive Inspection

This bureau is charged with the enforcement of the Locomotive Inspection Act, which has for its purpose the promotion of safety of employees and travelers upon railroads by prohibiting the use of locomotives that are not in proper condition and safe to operate.

The provisions of the act are broad in scope and set up a general safety standard. Rules and regulations established under the authority of the act contain requirements as to equipment, tests, inspections, and minimum standards of construction and maintenance applicable to steam locomotives and locomotives propelled by power other than steam.

Responsibility for general design and construction and for the making of proper inspections and repairs is placed primarily upon the carriers. Inspections are

required after each use of a locomotive, and the carrier is required to see that proper repairs are made before the locomotive is returned to service. Monthly and annual inspections and repairs are also required, and reports are filed showing the condition of each locomotive at the completion of these periodical repairs.

The field force, consisting of district inspectors having headquarters at various points throughout the continental United States, make such personal inspections of locomotives as may be necessary to carry out the provisions of the act. Inspections are made of locomotives owned or used on the lines of all common-carrier railroads. At the present time these carriers have in use 61,947 steam locomotives and 1135 locomotives propelled by power other than steam, which are housed or repaired and inspected by district inspectors at approximately 4600 different places. Under the law a district inspector may order any locomotive out of service which does not conform to the requirements of the law or the rules and regulations established and approved as provided therein, subject to appeal by the carrier to the chief inspector, and in turn to the Commission.

Accidents ascribable to failure of a locomotive or any of its appurtenances from any cause and which result in serious injury or death to one or more persons, are investigated and the cause determined, and, if found due to faulty equipment, appropriate steps are taken to prevent recurrence.

The first requisite, or the foundation, for safe locomotives is safe construction, and in order that this may be assured the carriers are required to file specifications covering constructional details of each new locomotive, as well as reports of any subsequent structural changes that may affect safety.

These specifications are checked by engineers connected with this bureau to determine whether the design, construction, and equipment of new locomotives comply with the safety standards set up by the law and rules, to follow up subsequent structural changes that may be made in the course of repairs or rebuilding, to determine whether such changes adversely affect safety, to examine proposed constructions and devices to determine whether their use may be permissible under the terms of the act, and to perform such engineering services as may be necessary in connection with investigations of accidents.

SAFETY

The Bureau of Safety is engaged in the enforcement of the various safety-appliance acts, the hours-of-service acts, medals-of-honor act, accident-reports act, and section 26 of the Interstate Commerce Act which gives the Commission authority to require installations of train control, block signals, or other safety devices upon the line of any railroad.

In connection with the equipment of railroad vehicles with safety appliances, investigations are made to determine whether or not equipment provided by the manufacturers and railroad companies for different classes of vehicles conforms to the requirements of detailed specifications prescribed by the Commission covering the number, dimensions, location, and manner of application of the required devices. Instances are frequent in which cars manufactured, or proposed to be built, do not conform strictly with any of the different classes of equipment for which detailed specifications are provided, and in such instances consideration must be given by the bureau to the type of construction of this special equipment, and to the provision of safety appliances properly adapted to it so as to be adequate to safeguard train-service employees.

The bureau is also required upon request of the Post Office Department to determine and pass upon the structural condition of cars used in railway mail service.

The Commission has prescribed specifications and requirements for automatic train-stop and train-control devices, and has required certain specified carriers to install such devices on designated portions of their lines. These installations are subject to inspection and approval by the Commission. In these devices various combinations of electrical, mechanical, and pneumatic equipment are employed, and detailed examinations of all such equipment installed under orders of the Commission are made by engineers of the bureau. Reports are submitted setting forth in detail information as to whether such apparatus is designed, constructed, and installed so as to conform to the specifications and requirements prescribed by the Commission, and upon the basis of such reports the Commission grants or withholds its approval of the required installations. Periodic inspections are also made to determine whether or not the equipment is properly maintained so as to be safe and suitable for daily service.

In connection with the developments and improvement of automatic train-control equipment, tests and experiments are frequently made by manufacturers and railroad companies in which engineers of the bureau cooperate. These engineers are also at times called upon for assistance in determining causes of failures or other troubles incident to the use of these appliances.

The bureau conducts investigations of practically all serious railroad accidents. These investigations often present engineering problems involving the construction and maintenance of track, the design and construction of all types of rolling stock, installations of signals and interlocking, and failures of rails, wheels, axles, and other railroad materials. These investigations also include both field and laboratory tests for the purpose of establishing the causes of these accidents, determining preventive measures which should be employed, and the precise causes of failure of railway materials. In this work the bureau has had the cooperation of the railroads, rail, wheel, and other equipment manufacturers, the Navy Yard, and the Bureau of Standards, and has utilized laboratories and shop facilities of all of these organizations. The

bureau has conducted exhaustive tests to determine the causes of transverse fissures in steel rails, and to develop means for detecting these and other internal defects.

The Commission is authorized by law to investigate and report upon any device intended to promote the safety of railway operation. Plans of various appliances of this character are constantly being submitted for examination and report by the engineering staff of the bureau.

The bureau is cooperating with the Mechanical Division of the American Railway Association in extensive tests of new types of air-brake equipment, which have been in progress for several years at the Engineering Experiment Station of Purdue University, and which are now in progress on the lines of the Southern Pacific Company in Oregon and California. It is also cooperating in the same manner in tests of automatic train-pipe connectors which are now in progress at Purdue University. In this work it assists in determining upon the devices to be tested, preparing the schedule of tests, and in the actual conduct of tests and analysis of results.

SERVICE

This bureau deals with matters relating to car service, transportation of explosives and other dangerous articles; transportation of commodities requiring refrigeration en route, and efficiency and economy of operation.

In the matter of car service, the bureau, through its representatives located at strategic points throughout the country, keeps in touch with the needs of shippers and the movement of equipment in order to be in a position to minimize, or forestall, interruption in dependability and continuity of transportation. In the event of congestion of traffic, shortage of equipment, or other emergency, the Commission is empowered to suspend the operation of the carriers' car-service rules and to issue such directions as may be necessary with respect to the distribution of equipment without regard to ownership, to require such joint or common use of terminals as will best meet the emergency, and to give directions for priority or preference in transportation, embargoes, and movement of traffic under permits.

Regulation of the transportation of explosives and other dangerous articles from the viewpoint of safety necessitated the promulgation of specifications covering the construction of containers in which the various commodities could be shipped and a code of rules governing packing, loading, and movement over carriers' lines. Additions to and amendments of the specifications and rules are made from time to time to keep pace with changes in conditions. This work involves the services of engineers who determine the suitability and safety of design of all types of containers, ranging from small containers to tank cars carrying high pressures, used or proposed to be used, in the transportation of explosives and other dangerous articles. In this work the Commission receives the cooperation of other interested branches of the Government and the Bureau of Explosives of the American Railway Association.

Another activity of the bureau's engineers is participation in service tests of refrigerator cars to determine the merits of various types and constructions of cars and the efficacy of various methods of refrigeration. This phase of the work is performed in cooperation with representatives of the Department of Agriculture.

In connection with efficiency and economy of operation, studies are made by engineers where excess expenditures are apparent. One of the important activities has been the investigation of costs of repairs to locomotives and other equipment at contract shops, as contrasted with what it would have cost the carrier to have the repairs made in its own shops. Contracts and agreements covering repairs to rolling stock and floating equipment made at outside shops are reviewed, and field investigations are made when deemed advisable. Matters pertaining to expenditures for maintenance of way, rental of equipment, reclamation of material, and other items are also the subject of engineering studies and investigations.

STATISTICS

The functions of the Bureau of Statistics are to collect and compile in suitable report form for the information of the Commission, other branches of the Government, and the public, statistical facts concerning the corporate history, organization, investments, capitalization, indebtedness, physical property, and operations of all common carriers subject to the Interstate Commerce Act; also to show by suitable exhibits financial changes, taxation, contracts, revenues, expenses, number of employees, traffic, operation, maintenance, and other particulars relative to such carriers. The result is that today there are available to the public, the carriers, and the Commission reliable comparative data upon all matters relating to railroad operation. This bureau receives and analyzes all annual reports and other statistical reports filed by carriers, and maintains a reference room for the use of the public, with a representative of the Commission in charge for the purpose of assisting interested parties to the fullest utilization of the vast amount of data which has been compiled.

TRAFFIC

The Bureau of Traffic embraces the administrative functions of the Commission bearing directly upon the charges for transportation, including freight and passenger rates and miscellaneous charges of common-carrier railroads, steamship lines, and pipe lines, and other charges for transportation and of transportation companies engaged in interstate commerce. It also acts in an advisory capacity in connection with the disposition of formal cases, settles through informal negotiations between shippers and carriers many con-

troversies without litigation, and handles all administrative matters connected directly with rates and tariffs.

VALUATION

The Bureau of Valuation was organized in 1913 for the purpose of determining the value of property in the United States that is used for common-carrier purposes.

The Commission decided to undertake the valuation of the steam carriers and telegraph carriers first. For the purpose of making a field inventory, five district offices were established, at Washington, D. C., Chattanooga, Tenn., Chicago, Ill., Kansas City, Mo., and San Francisco, Calif. An engineering board composed of five members and reporting directly to the director of valuation was appointed to have charge of this work. Each one of the members of this board had charge of the work in one of the districts. In addition, the district organization consisted of a district engineer and heads of various classifications of the work, such as roadway items, bridges and buildings, mechanical, equipment, signals, telegraph, etc. A large field organization was assembled consisting of about sixty roadway parties, each being in charge of an assistant engineer, who had under him computers, recorders, instrumentmen, rodmen, and chainmen. These parties were housed in cars fitted up for permanent living and working quarters. Each district was given the task of inventorying about the same amount of physical property. A complete field inventory was made of every physical item that entered into the construction of railroad property. The notes were made with an original and duplicate; the duplicate copy was given to interested carriers, who were represented in the field by a pilot and the necessary number of assistants. The duties of the pilot were to see that no items were overlooked. In addition to these roadway parties, there were field parties composed of two or three men who inventoried bridges and buildings, and other parties who inventoried signals, equipment, telegraph, and various other kinds of property. These field parties also determined the physical condition of the property based on an estimate of the probable total service life of the item and the expired service life, with due regard to salvage, if any.

The appraisal of rights of way and terminal lands, as distinguished from other property, involved a number of phases of engineering. Included with land are various rights such as riparian rights and certain mineral rights. Some of this work follows lines more or less conventional and pertinent to the engineering profession, while other aspects include work that is peculiar to the technique of land valuation, somewhat foreign to engineering as strictly defined, though where engineering training is found to be one of the desirable qualifications.

After the completion of the field work the district offices were discontinued and the entire organization brought to Washington, where the engineering reports of the properties were completed as of various valuation dates. These reports were served on the various carriers. Time was given to file objections; informal conferences were then held with each carrier's representatives and a revised report prepared which was made a part of a tentative valuation of the carrier's property which was served on the carrier. After receipt of the carrier's protest, if any, a hearing was held before the Commission's examiners, at which testimony was presented by the bureau's engineers to support the field work and pricing which had been used in the prepation of the reports. Finally a revised engineering report was prepared to comply with the Commission's decisions in the various valuation cases.

The same general procedure was followed in the telegraph work; however, there are only two major companies, the Western Union and the Postal Telegraph-Cable Company.

Since the completion of the preliminary or original valuations, engineers have been occupied with bringing the valuations down to various dates so as to determine a valuation of the physical property to be used as a basis by the Commission for securing a return of excess income from the carriers under Section 15a of the Transportation Act. This work involves an adjustment of the original inventory for the net changes in the property due to additions, betterments, and retirements, which changes are reported to the Commission by the carrier in detail.

In connection with the carriers' detail reports of changes, engineers work coordinately and jointly with accountants in determining the accuracy of the reports in so far as changes such as new constructions, additions, betterments, and retirements are concerned, and their conformity with prescribed rules and regulations. This work involves inspections of property, the making of inventories of such property, investigations leading to the determinations of the reasonableness of quantities reported and proper classification thereof, and other related matters.

CONCLUSION

In order that a more comprehensive view of the relation of engineering to the work of the Commission may be obtained thereby, I have attempted to describe the general character of work in which engineering talent is engaged, and the character of other activities that are at times closely associated therewith, rather than to define the classifications and detail duties from an engineering standpoint alone.

From this it is clear, therefore, that the services of our engineers form an essential part of the work of the Commission. Engineering training develops to an extraordinary degree the habit of orderly, concentrated, and effective thinking, the ability to assemble and digest facts, the ability to separate the essential from the non-essential, and the ability to reason from cause to effect. The scope of the various laws administered by the Commission is such that it requires engineering assistance of practically every kind that is necessary in railroad construction or operation.

A Russian Engineer on American and German Technique[1]

THE American, capitalist as well as engineer, is thoroughly practical. He is persistent in bringing into reality, every logical technical idea which promises a profitable application, but he does not utterly abandon promising ideas which have not yet assumed logical form. The American seeks the greatest simplicity in the solution of technical problems. Frequently he finds an accidental and simple solution, but does not establish the fundamental reason. The tremendous scale of economic life in the United States compels the American engineer to resort to bold constructions, the efficiency and versatility of which are surprising.

One especially characteristic American procedure is that of combining many operations in one machine to accomplish one complete technical process, peculiar value being placed on light construction of each part. The reduction of idle time of such a machine is held to be more important than a saving in the time of manufacturing each part. In machinery designed for particularly important operations and which may be subjected to heavy fluctuating loads and impacts, the American does not hesitate to increase the cross-sections 25 to 30 per cent over that which his strength and stiffness calculations indicate. He starts with the premise that it is more important to reduce the cost of production of the product of the machine than to reduce the cost of the machine itself.

The foregoing relates only to the construction of single products. For quantity and mass production, the American freely employs special steels and alloys to attain continuity of operation. At the same time he seeks to reduce costs of production and assembly through industrial management.

Notwithstanding all these advantages, American technique has numerous drawbacks. The dependence of the American designer upon practical experience leads him to neglect scientific investigation in the solution of questions of construction. He is more an inventor than a researcher. This explains why the Americans are outstanding in all spheres which embrace chiefly the purely practical viewpoints and experiences (for example, machines for road building, mining, petroleum distillation, metal working, materials handling, etc.), while they are significantly weak in those depending upon the fundamental toilsome results of theoretical research such as constructions for the chemical industries and for high pressures.

The technical science of Europe, and in particular, Germany, is distinguished principally from that of America in that it serves to a greater extent the realm of scientific investigation, which sometimes opens wide horizons and radically changes existing technical views. It is only necessary to point to Germany's success in the realm of applied chemistry, chemical-plant construction, reduction of nitrogen from the air, the development of pressures up to 1000 atmospheres, measures to protect metals against corrosion, stainless steels (Krupp V2A), high-speed steels (Widia) and the widespread application of autogenous welding.

In general every new creation of the German machinery industry carries the stamp of rich mental analysis and scientific control of investigations. The improvement and simplification of existing forms rather than a search for new forms and new ideas in machine construction, distinguishes German technical science from the American—for example, the renaissance of the reciprocating steam engine as a high-pressure machine. Since German constructors build to a large extent for foreign markets, they cannot afford to use more material in a machine than what their computations indicate. This, together with the more economical use of expensive metals and alloys, cheaper labor and materials, and finally especially careful and economical plant management, places the German machine industry in a position where it is possible to deliver machines in no wise inferior to American products but which are up to 40 per cent cheaper in price.

In regard to the Russian machinery industry, Perelman arrives at the conclusion that it would not be suitable to copy blindly either American or German designs. It is preferable, he says, to draw on the German technique whenever an inexpensive machine with economical use of materials is required, or when the criterion is not simplicity of construction or application but the technology of the process for which the machine is proposed. In this sphere are gas producers and purifiers, condensers and heat-transfer devices, driers, filters, etc. Further, in those forms of construction which depend upon thermodynamics, as, for instance, boilers, engines, compressors, and pumps, more can be expected from Germany, the classical country of thermodynamics, than from America where German technique has been taken over in fully developed form. In order to acquire the Americans' success in the machinery industry, one should address himself not so much to their fundamental scientific methods as to their experience in mass production—for example, in the building of tractors, combines, and other complicated agricultural machinery, automobiles, electrical machinery, furniture, railroad cars, etc. Moreover, with the present common front of world technique, universal technical journalism, and the fact that there are no longer any manufacturing secrets, there can be no such material superiority in one construction over another as to justify a 40 to 50 per cent higher price.

[1] It is important that a country, like Russia, which seeks to improve its economic and industrial status through foreign assistance, shall have a knowledge of the fundamental limitations of the technique of the great industrial countries. With this in view, L. Perelman not long ago discussed the engineering methods of Germany and America, the leading countries whence Russia is deriving technical assistance, in an article in the Russian journal, *Sa Industrialisaziju*. In the belief that his deductions would interest its readers, the article was abstracted in the *V.D.I. Nachrichten*, Berlin, March 25, last. MECHANICAL ENGINEERING is indebted to Frederick Franz, Mem. A.S.M.E., Consulting Engineer, New Haven, Conn., for the present translation from the German.

A 15,000-Lb. Booster Gas Compressor

Particulars Regarding a Hyper Compressor Designed to Operate With an Inlet Pressure of 3000 Lb. and a Final Discharge Pressure of 15,000 Lb. per Sq. In., For Use at the Fixed-Nitrogen Research Laboratory, Washington, D. C.

By J. R. DILLEY[1] and W. L. EDWARDS,[2] WASHINGTON, D. C.

THE continued application of high pressures to commercial processes has presented many problems, the solution of which has required a radical modification in established engineering practice.

In designing equipment for those processes using gases at high pressures—that is, pressures as high as 15,000 lb. per sq. in.—a complete knowledge of the physical properties of the gaseous medium employed is essential. It is important to realize that, at these pressures, actual gases deviate considerably from the simple rule of the ideal gas, and any attempt on the part of the engineer to make computations based on the laws of the ideal gas, as is usual in most engineering practice, would lead to serious errors.

To obtain the reliable data on which the physical properties of gases are based requires a large amount of scientific research, and for this work a safe and easy method of obtaining high pressures is needed.

At the Fixed-Nitrogen Research Laboratory of the U. S. Department of Agriculture, a gas-compression system[3] using hydraulic pressure has been employed for compressing gases to high pressure. In this system gas is compressed, to the desired pressure, over a water column actuated by a hydraulic pump. This method, although safe, is also slow, and is not without its troubles and inconveniences.

In order to avoid the difficulties of operating and maintaining high-pressure hydraulic pumps, and to provide an easy and rapid means of compressing gases, there has been designed and built, at the Fixed-Nitrogen Research Laboratory, a booster compressor capable of developing pressures up to 15,000 lb. per sq. in. In designing this compressor, space conservation was an item of interest, as was also the desire that the compressor require little or no operating attention. In choosing an inlet pressure, the availability, due to existing compressors, of gas at 3000 lb. pressure was an important consideration. The apparatus on hand for producing a sufficient quantity of gas was a determining factor in the gas used for the experimental work. Although the compressor has been operated exclusively on a hydrogen-nitrogen mixture (75 per cent hydrogen, 25 per cent nitrogen), it is no doubt suitable for other gases, oxygen excepted.

Foreign manufacturers have taken the lead in the development of the so-called "hyper" compressors, that is, those working at a final pressure of 15,000 lb. The starting point in the development of these machines dates back to the time Claude first advocated the use of these enormous pressures for the production of synthetic ammonia. Hyper compressors differ considerably in type and design. Compressors are built for 15,000 lb. pressure with as few as five stages and as many as seven and nine stages; some are vertical, others horizontal; one type has the low-pressure cylinders horizontal and the high-pressure cylinders vertical. In general these compressors operate with an atmospheric suction pressure, although one manufacturer has the high-pressure cylinders so separated they may be considered an independent machine.

The Fixed-Nitrogen Research Laboratory compressor is a booster compressor designed to operate with an intake pressure of 3000 lb. and a final discharge pressure of 15,000 lb. The type of drive used makes a compact construction requiring a floor space 3 ft. × 4 ft., although the base is only 14 in. × 27 in. The overall height of the machine is 6 ft., 6 in. Fig. 1 is a reproduction of a photograph of the compressor and operating equipment. Figs. 2 and 3 are sectional views showing the interior arrangement.

The compressor has a single vertical cylinder with a single-acting, plunger-type piston having a working stroke of 8 in. The compressor is driven by a direct-connected motor and requires at maximum pressure approximately 10 hp. When operated at a motor speed of 720 r.p.m. the compressor has a displacement of 1/4 cu. ft. per min. Although this displacement is small, the intake volume, for the gas with which the experimental work was done, is 45 cu. ft. of free gas per minute. The free-gas intake volume will depend upon the compressibility of the gas being used; if working with an ideal gas the intake volume would be 50 cu. ft. of free gas per minute.

The lower frame, in which the driving mechanism is enclosed, is of cast iron and is extended to form the

---

[1] Associate Mechanical Engineer, Bureau of Chemistry and Soils, U. S. Department of Agriculture. Assoc-Mem. A.S.M.E. Mr Dilley received his M.E. degree from Lehigh University in 1915. He has been associated with the Corn Products Refining Co., Chicago, and with the American Woolen Co. Since 1925 he has been engaged in engineering work relating to the fixation of nitrogen and allied processes at the higher pressures.

[2] Associate Engineer, Bureau of Chemistry and Soils, U. S. Department of Agriculture. Mr. Edwards received the degree of C.E. from Lafayette College in 1915. He has served in engineering and designing capacities in the Taylor-Wharton Iron and Steel Co., the American Cyanamid Co., the U. S. Army Ordnance Department and the U. S. Army Engineers. For the past eight years he has been engaged in engineering and design work relative to synthetic ammonia, ammonia conversion, and high-pressure equipment.

[3] Dilley and Edwards, U. S. Dept. of Agriculture Circular, 61 (1929).

base of the machine. Convenient handhole plates permit access to the gear case. The two end plates, stiffened with external radial ribs, are extended and bored for the long bearings, which are provided with removable bushings.

A special metallic packing developed at this laboratory is used in the stuffing box. The packing is divided into three units, separated by oil lanterns. The packing elements, made of a lead-tin alloy, are separated by steel rings. These diamond-shaped rings are made with varying angles so that an even tightening of all the packing elements is obtained. Bronze bushings above and below the packing serve to guide the piston.

Experience gained so far in actual operation indicates that the stuffing box is of greater depth than necessary, that is, more rings of packing are being used than are required to maintain a gas seal. Shortening the stuffing box would permit a reduction in length of the plunger and materially decrease the friction on the plunger.

The cylinder, of chrome-vanadium steel, is made with an enlarged head in which the valves are placed. Inlet and discharge valves are the same size and are made of a good grade of steel, hardened, and ground to size. The flat disk valves are especially adapted for high pressures and are wing-cut, allowing sufficient gas passage with small lift. The seats, cut directly in the head, are narrow, thus reducing the pressure differential required for opening the valve. The heart of any compressor is the valves, therefore it was natural, before obtaining successful operation, to experience more difficulty with the valves than with any other part of the machine.

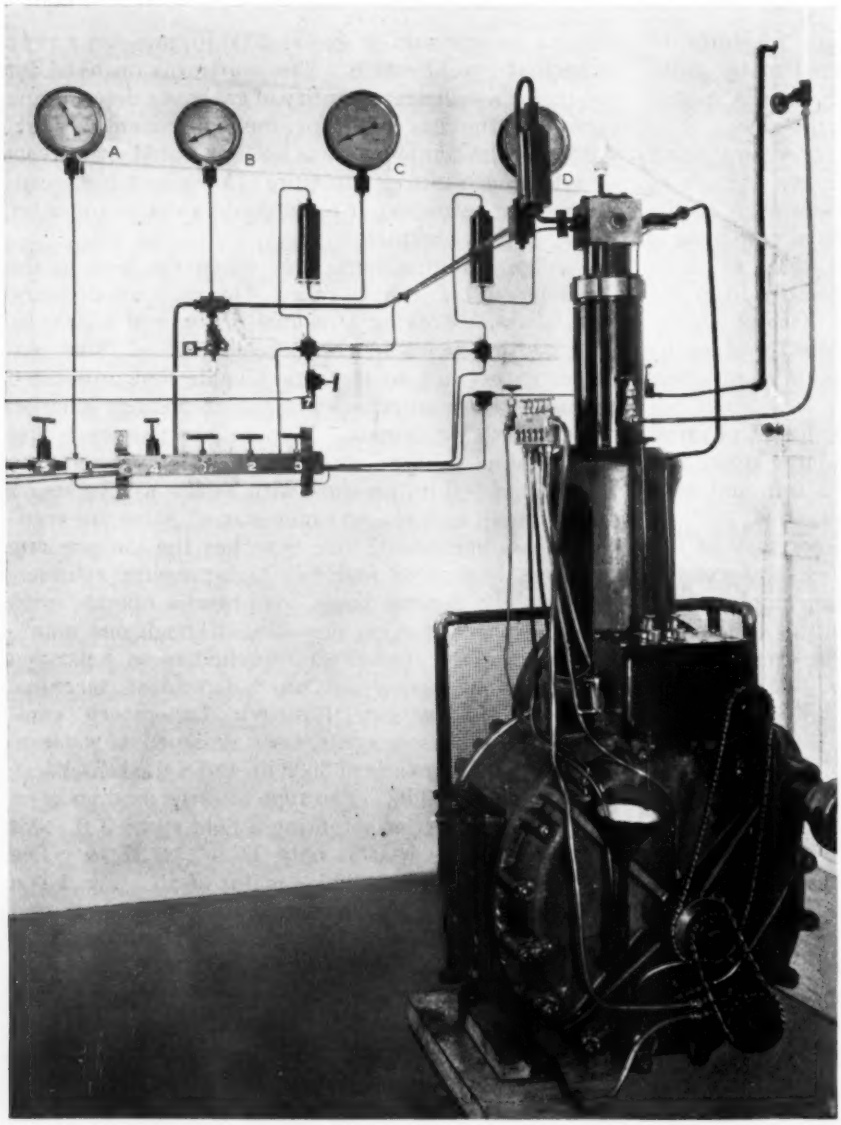


FIG. 1 VIEW SHOWING 15,000-LB. BOOSTER COMPRESSOR AND OPERATING EQUIPMENT

The stuffing box is contained in a heavy cylindrical casing separate from the cylinder but joined to it by a large threaded collar and slotted nut. An open-type distance piece connects the stuffing-box casing and cylinder with the driving end.

The stuffing-box casing and cylinder have separate water jackets, the cooling water flowing from one to the other and finally out through drilled passages in the head.

One of the interesting features of this compressor is the method of obtaining rectilinear motion. In place of the usual crank there is a combination hypocycloidal-gear mechanism and eccentric drive. The use of either one of these mechanisms for obtaining straight-line motion is by no means new. The eccentric drive is common in its application to small compressors and pumps, and the gear mechanism is used on other machines. However, the application of the hypocycloidal motion to a compressor is unusual, while the combination of the two is worthy of notice.

Keyed to the main driveshaft are two fiber pinions, which deliver the power to the two driving spur gears, one on each side of the machine. These gears not only transmit the power but also reduce the speed to that desired. Fastened to each side of the inner frame is a large stationary internal gear. Meshing with each of the internal gears is a pinion, which is free to rotate. These pinions are integral and have the portion be-

tween them enlarged into a disk, which is made into an eccentric. The number of teeth of the pinions and internal gears are as one to two.

Keyed to each of the driving gears is a crank, the driving pins of which fit loosely in the pinions. The uniform motion of the cranks is imparted to the pinions, which roll around the inside of the internal gears and carry the eccentric with them. The eccentric strap, bolted on the eccentric, has the upper portion made in the form of a cylindrical enlargement or gudgeon. The eccentric rod, which takes the place of the usual connecting rod, is connected to the eccentric strap by the gudgeon pin. The piston has a shoulder on the lower end by which it is locked to the eccentric rod with a nut.

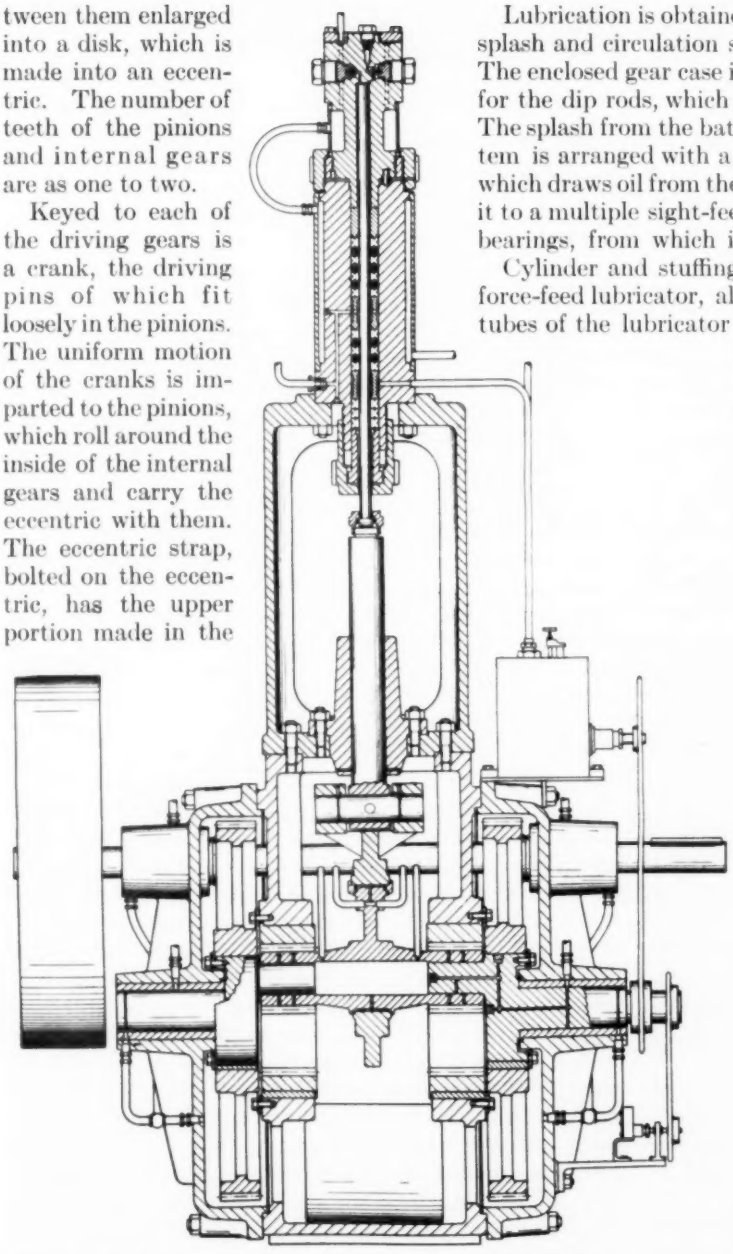
The principle involved in the use of the hypocycloidal motion requires that the driving pin be placed at a point exactly on the pitch circle of the rolling gear. The difficulty of making this driving pin sufficiently strong to carry a heavy load has been overcome by using an eccentric and distributing the load over two driving pins.

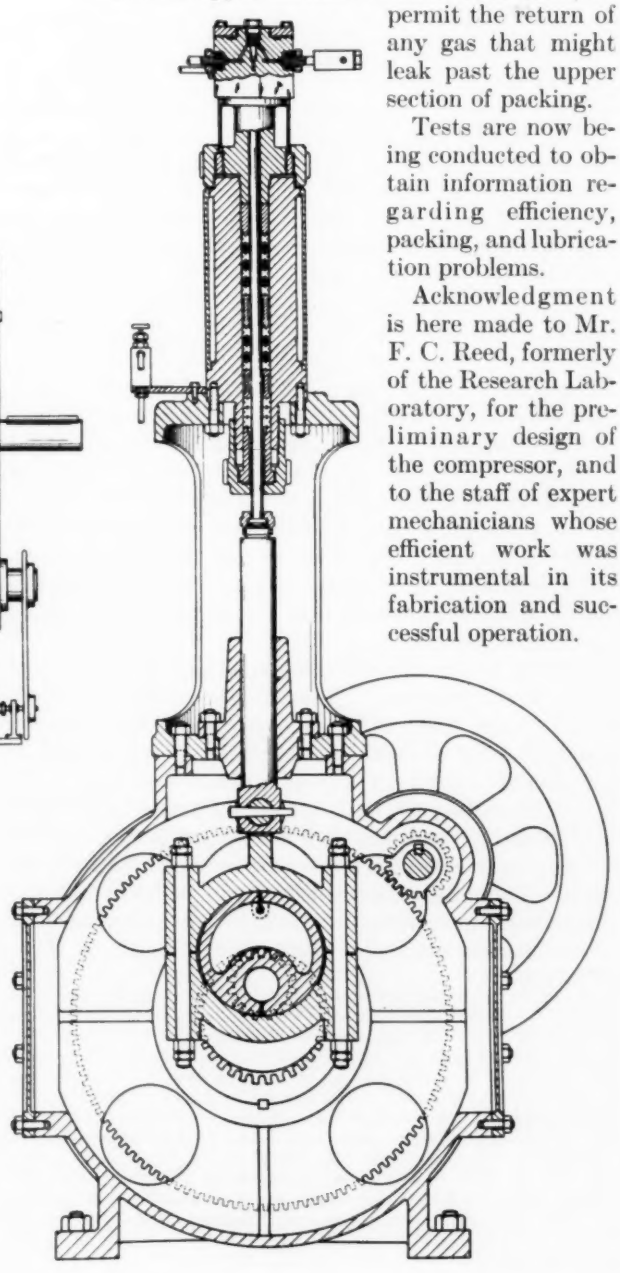
Lubrication is obtained by two separate oiling systems. A combined splash and circulation system provides oil for the gears and bearings. The enclosed gear case is partially filled with oil, thus providing a bath for the dip rods, which supply oil through drilled holes to the eccentric. The splash from the bath carries oil over the gears. The circulation system is arranged with a small gear pump (chain driven from the shaft) which draws oil from the compressor base through a strainer and delivers it to a multiple sight-feed oiler. From here the oil is distributed to the bearings, from which it flows back by gravity to the gear case.

Cylinder and stuffing-box lubrication is provided by a mechanical force-feed lubricator, also chain driven, with two deliveries. One of the tubes of the lubricator delivers oil through a check valve to the suction inlet. The other tube leads to the lower lantern of the stuffing box. A relief pipe leads from the upper lantern to the suction inlet, to permit the return of any gas that might leak past the upper section of packing.

Tests are now being conducted to obtain information regarding efficiency, packing, and lubrication problems.

Acknowledgment is here made to Mr. F. C. Reed, formerly of the Research Laboratory, for the preliminary design of the compressor, and to the staff of expert mechanicians whose efficient work was instrumental in its fabrication and successful operation.





FIGS. 2 (*above*) AND 3 (*right*): SECTIONAL VIEWS OF 15,000-LB. BOOSTER COMPRESSOR SHOWN IN FIG. 1

Work-World Environments

Light and Color Fundamentally Desirable and Powerful Influences Upon Happiness—Color Schemes for Factory Interiors and Machinery—Economic Value of Pleasant Environments for Workers

By M. LUCKIESH,[1] CLEVELAND, OHIO

COLOR is the music of light. It provides much of the finery of the world about us. It can reduce the monotony by introducing variety . . . . Adequate and proper lighting, orderliness, cleanliness, pleasing color schemes, improved seeing, attitude, outlook, contentment! In many work places all these factors of modern civilization cannot be introduced. However, much improvement is possible everywhere, and in much of the work world pleasant environments are entirely practicable. If we are to fully capitalize our knowledge and resources certainly we must produce environments eminently satisfactory to the emotional being, which is an important part of the worker. The beneficial results would be both tangible and intangible. Even if the worker produced only the same amount of work but with a lesser output of human energy—physical, nervous, and mental—the objective would be worth while.

AS WE CONTEMPLATE the exterior world, as appraised by the visual sense, we find colors provide a magical drapery—a heaping measure already filled with the marvelous beneficence of seeing. To a color-blind person the exterior world consists of brightness and form from which color is excluded. To him the world is done in grays, but he does not miss the colors if he has never experienced their sensations. To one who has color, even for the most part with a slumbering consciousness, a sudden visitation of color blindness would project him into an environment in which he would be conscious of a certain degree of monotony. This new gray world perhaps would seem something like a penitentiary whose colorless, monotonous environment certainly must emphasize variety as the spice of life. Color is the music of light. It provides much of the finery of the world about us. It can reduce monotony by introducing variety.

Human beings are still fundamentally the product of nature's environment. The indoor world is a very recent environment which has not appreciably changed human behavior toward fundamentals, even though it has altered man's viewpoint and attitude considerably. Notwithstanding the deep-seated influence of nature's light, lighting, and color, civilized man is not content to enjoy only the color and colorings which nature provides. In building the artificial world, which is material civilization, numberless man-made colors are utilized for numberless purposes. Even in the relatively short time that man has made his own colors and applied them, the subject of color has become a gigantic complexity. But, however large and intricate a subject is, it may be systematically taken apart. In what follows a new and somewhat tangled aspect will be discussed which, however, is pertinent to all of us as workers and as human beings.

In a broad sense we are just beginning to use color. We are primitive beings in this and in many other ways, as the future is bound to prove. But primitive beings, as we term them, used nature's colors pure and relatively sparingly. As man became cultured he used colors in more ways, but also subdued or diluted them. As we look over the paintings of last century, for example, we are suspicious that even painters were afraid of color. Witness the "taupe age" in home furnishing, which is even now only disappearing. In those interiors a spot of real color would seemingly shatter the imposing silence of a monotony of grays or thrice-subdued colors. If more evidence of cowardice toward color is needed, look into the white bathroom, kitchen, or hospital, which shouts cleanliness at us. This whiteness seems to say that the housekeeper would not be meticulous in colorful surroundings. These and many other details convict past generations of shortcomings in regard to the employment of color in making our artificial world a more interesting place in which to spend so much of our lives.

The slow general progress of civilization is punctuated and accelerated by the impetus of revolutions. What we broadly term "Art" is no exception. The Renaissance was not only a revolution in art; it was a declaration of independence from the old order in many aspects of civilized thought and action. The new and extended uses of color are only a part of another general revolution. In art a new declaration of independence was ready to burst forth with the beginning of the present century. Most of us remember the first extensive exhibitions of modern art about a score of years ago. Form and color were trying to escape the shackles of realism. Many of the products of revolutionary ar-

[1] Director, Lighting Research Laboratory, General Electric Company, Nela Park. Dr. Luckiesh was graduated from Purdue in 1909 as a B.S. in E.E., and received the degrees of E.E. from Iowa State College in 1911, and M.S. from the State University of Iowa in 1912. In 1910 he joined the staff of the Nela Research Laboratories as physicist, and in 1920 became director of applied science of that organization and the National Lamp Works of the General Electric Co. His present position dates from 1924. During the war he was chairman of the camouflage committee of the National Research Council. In 1926 he was given the degree of D.Sc. by Iowa State College. He is a member of many scientific societies, has written numerous authoritative works on color, lighting, ultra-violet radiation, etc., and has been a frequent contributor to scientific and technical journals.

tists could not be understood. Doubtless the artists were not certain of their ground. Perhaps those earlier products of the revolution are to be considered as experiments in a new realm of intent and function.

Within very recent years color has been emphatically augmented in decoration and paintings; in the theater, home, and other interiors; in various phases of lighting; and in an ever-increasing variety of commercial articles. Some consider this riotous use of color as a natural effort at relief from the dark, gray thoughts and experiences during the World War. However, there is plenty of evidence which proves that this new era of color was well germinated before the war began. Of course, current conditions influence the progress of a revolution, and doubtless the enhanced prosperity following the war accelerated the use of color. Certainly prosperity has always expended much of its resources upon comfort and beautification. Nevertheless, the author bases the present discussion largely upon the premise that light and color are fundamentally desirable and powerful influences upon happiness.

DEMAND FOR COLORS IN RECENT YEARS REAL AND INSISTENT

That the demand for color has been real and insistent is evidenced by the sale of colored articles. In 1924 the *Saturday Evening Post* printed its first four-color insert of full-color advertisements for which the publisher received $210,000. In 1929 this magazine scheduled 1307 four-color pages, and the gross receipts were more than $15,000,000. These figures are powerfully significant beyond the narrow view of advertising. They are proof of the appeal of color and of the enormous growth in the use of color on packages and products. Another proof of the demand for color is found in the automobile. All of us have an idea of the cost of the futile opposition to the introduction of color by our most celebrated individual in the automobile industry. We all know that he eventually capitulated to this demand for color. Evidence of this sort is already available from many commercial experiences. Much of the evidence supports the conclusion that the demand for color very generally springs from the depths of the emotional being, and that it is not created by products and advertising. The desire for color has always been present, even though slumbering for the most part. It is quite natural for the work world to be the last frontier to be crossed by color.

Although many advances have been made in regard to the welfare of the people of the work world, it is not difficult to prove that in certain very important respects the executive attitude toward workers resembles that toward work horses more than that toward human beings. The sensible employer provides well for the physical care of work horses, and he does likewise with workers. However, a worker differs from a work horse very markedly. He is a work horse and emotional being combined.

We are justly proud of the achievements of this machine age, but really what has it done for the emotional being which also inhabits the worker? Machine-mindedness has been the dominating influence in the work world during recent years. It is quite natural that to machine-minded executives, workers have taken on the aspect of machines, and that machine-mindedness has little room or training for constructive thinking pertaining to the emotional part of the human being. There is even plenty of evidence that little consideration is given to the senses which distinguish a human being from a machine. Witness lighting at the present time. It is a partner of vision in the product of seeing. Eyesight is the most valuable part of a human machine; still, the best lighting of today is primitive indeed compared with that of outdoor lighting for which human eyes were designed. At best the practice of lighting is based upon production and not upon ease, comfort, and conservation of vision. Its value is judged in terms of production of workers. But other factors, such as muscular reactions and natural gait of hands or arms, limit the increase in production before illumination intensities reach those values the eyes need for easy and comfortable performance of their tasks. But the latter are intangible values, and, besides, it is common experience that machines wear out. Therefore the intangibles are left out in appraising the value of lighting. Productive work is the measuring stick regardless of the output of human energy and of the wear and tear upon the human machine.

Although lighting is closely associated with the subject under discussion, it is not the intention to discuss it in detail. It is introduced to afford an opportunity to prove that the present consideration of workers does not include the visual sense or the emotional aspect.

Of all man's senses, vision contributes most toward his usefulness, sensitiveness, and happiness. When the visual sense fails it is calamitous, for the main doorway of impression has been closed. The blind person is hemmed in by a screen, impenetrable but for the sounds of the world out of reach and for the touch of things near at hand. The modern hope and aim are not merely to work for a living, but to live while working. The visual doorways make this possible, if what workers see surrounding their specific visual tasks increases their usefulness and happiness. Light, color, and lighting can accomplish this because the impressions gained through the eyes rank first in number, in variety, in appeal, in importance, in vividness, and in permanency.

Let us try to understand and to classify people in respect to esthetic sensibility, and particularly in respect to their reactions to light and color. These sensations influence human beings definitely, and in many respects quite uniformly, regardless of race, nationality, and culture. Through climate, culture, and usage, reactional differences are found among races and nationalities. Esthetic sense and popular taste appear at first sight to complicate the matter, but when the depths are plumbed, individuals of the same civilization are fundamentally quite alike regardless of state of culture. For example, there is little difference between

the absolute color preference of savages and cultured persons. When choosing color for color's sake alone, both these, representing the extremes of civilization, choose the pure colors. When associations are permitted to influence the choice, the savages hold to their pure colors, and the cultured sensitiveness of the civilized persons has been inclined to temper their choices to subdued tints and shades.

On every hand are to be seen the exhibits of individual taste (or lack of it) and of the popular taste of large groups differing in culture. Many of these exhibits are discouraging, for well-defined good taste is relatively rare. However, these are the expressions of persons who are impressed fundamentally alike, but who are unskilled in analyzing their own reactions and untutored in an art pertaining to which they have learned no rules. If the taste is guided or, better still, dictated by skilled persons with a broad esthetic experience and a deep practical knowledge, the surroundings where the millions work will be most suitable.

Classification of Mankind With Respect to Esthetic Sense

Civilized mankind may be divided into three classes as to esthetic sense:

1 A small non-creative group unconscious of beauty or of its absence
2 A very large, generally uncreative group, conscious of beauty when it is present, but practically unconscious of its absence
3 A small creative group keenly conscious of beauty and perhaps even more keenly conscious of its absence.

The first group is, fortunately, a very small one which is being diminished by education and associations. The individuals in this group are clods, guided by animal instinct and influencing progress about as much as work horses. To this group, necessity alone dictates.

The second group is the general public, of which the so-called workers form a large part. This group, as a whole, exhibits little useful imagination, and does not possess a cultivated esthetic sense. However, a common mistake is made in failing to recognize that they possess a rudimentary esthetic sense which, although dormant, can be aroused. The individuals in this very large group are influenced by their environment, whether consciously or not. Appreciation of esthetic surroundings can be awakened by the presence of such an environment; and even if this group is not alertly conscious of the absence of such a desirable environment, it is unfavorably influenced by this absence.

To the third group beauty and artistic surroundings are the real joys of living.

In the foregoing discussion *beauty* is meant to include everything and anything which arouses favorable reactions through the visual sense. Adequate lighting, which is free from glare, and fairly bright surroundings due to proper maintenance of reflecting surfaces, not only favor seeing but stimulate the worker and affect his attitude and emotions in a useful manner. To these may be added colorful surroundings, orderliness, and cleanliness. Perhaps the definition and influence of beauty in this sense may be further emphasized by the opposite picture. Certainly beauty does not encompass, and it may be destroyed by, harshness, discomfort, dirt, and disorder. Glaring light sources, harsh shadows, dingy surroundings, disorder, and lack of cleanliness are scarcely elements of an esthetic environment or favorable factors in arousing enthusiasm and cheerfulness. After all, the difference in the quality and quantity of the output of two human beings, who possess equal capacity as machines, is due in the long run to differences in mental state and attitude. Enthusiasm is an important prime mover in a human being.

Besides the profit to employer and employed, which may arise from the best environment compatible with the work to be done, there is a far-reaching effect. Viciousness, and eventually crime, are nurtured in dirt, disorder, and dinginess. If all persons could be exposed from infancy to at least simple and plain beauty, represented by orderliness, cleanliness, pleasing color and form, adequate light, and proper lighting, it seems reasonable to believe that a reduction in criminality would result.

Psychological Aspects of Light and Color

Colors have very definite psychological influences, but their emotive power is low compared with other factors which we enjoy. They are weak compared with the emotive power of good music or even of a good meal. They cannot compete in curative value with the proper pills. Still, in the work world they have little or no competition of this sort, and they can make their presence felt.

The following adjectives may be applied to colors and to color schemes:

heavy	dignified	warm	cool
solemn	neutral	glowing	airy
somber	tranquil	stimulating	dainty
gloomy	peaceful	cheerful	light
subduing	restful	exciting	gay
depressing	quiet	noisy	lively

This proves that there is a psychological foundation upon which environments may be developed.

In dealing with the psychological aspects of light and color, perhaps the most common error is to consider the effects to be stable, regardless of changes in other factors. This is a natural result of superficial acquaintance with the subject, and is the source of the glaring errors of the rule-of-thumb decorator who has just emerged from a thirty-lesson course. Such errors are not made by the graduate of years of practical experience, who realizes that the complexity of the subject invalidates all but the simplest rules for general application. "Appropriateness" is perhaps the briefest and most important rule. As one gains experience with reactions of human beings to light and color under a variety of conditions and associations, he learns that

something quite appropriate in one case is a miserable failure in another. The dual—or even multiple—nature of a human being, a lighting effect, a color, or a color scheme may be emphasized by a few cases bearing upon the subject.

Human beings reveal a dual nature in color preference, as has been adequately proved by scientific research. They fundamentally like the pure colors best, but they have very generally subdued color to live with. Possibly the latter is due to ignorance, cowardice, or to a misconception in regard to the relation of color and culture.

In order to understand human beings more, let us consider their attitude toward quality or color of light. Daylight is a natural illuminant in the daytime and for work places. Although it varies considerably in color, its range is generally from white to bluish white. From long experience and observation, we know that persons possessing highly developed esthetic sensibilities find daylight satisfactory in the daytime and even at night in a work place. However, at night in our homes most persons, who admittedly do not possess even a moderately trained esthetic sensibility, find artificial daylight undesirable. Even the yellowish white light of tungsten-filament lamps, if it is not tempered by warm-tinted shades, is very generally considered to be "too white." In brief, we reach the conclusion that human beings are of a dual nature in this respect also. The same individual reacts differently as a work being or play being—as a day being or a night being. A part of the explanation, at least, is found in the long association with the warm light of flames in our homes at night. Without entering into the controversy of environment and heredity, it is safe to state that the light from flames is as natural for our homes and recreational indoor world at night as daylight quality is for the work attitude common to daytime. Certainly since the dawn of civilization the warm-tinted light from flames has been associated with the interior which was home, no matter how primitive. That white or near-white light is not objected to in the work world at night may be explained by the common association of work with daylight. It is likely that artificial daylight or near-white light will eventually be found to be worth while in the work world from the psychological viewpoint.

Influence of the Color Scheme

In considering the introduction of a color scheme for ceiling, walls, columns, structural members, and machines, we need not limit ourselves to efficient light reflection any more than in homes and offices. The penitentiary color scheme—white and grays—may be efficient from a lighting- or plant-engineer's viewpoint, but is certainly not of highest efficiency from an emotional viewpoint. An appropriate color scheme must take into account the character of work done and other factors bearing upon maintenance. However, it is more important that the work being be considered along with all the associations and results of work. The color scheme generally should not be left to the plant engineer, for he is very likely to belong to the second or large group in regard to esthetic ability.

A color scheme which arouses the feeling of warmth and the comfort and cosiness which may go with it is quite suitable for the purpose of a home in which we rest. In the work world it is generally not difficult to keep warm. Perspiration is commonly associated with work. To feel cool is far more desirable in work places than to feel warm. Thus we arrive at one generalization—cool color schemes are more applicable than warm ones. A representative color scheme of the cool variety might be—

Gray green for dado and lower portions of columns, and possibly for machinery
Medium tint of pea green for upper walls and other large vertical areas
Near-white for ceiling—either a mere suggestion of yellowish green or even a cream
Medium tint of pea green for structural beams to give the feeling of support. If there are many beams, aluminum paint may be satisfactory.

It may be interesting to attempt to visualize the following color schemes and to compare them in the mind's eye with the penitentiary white and gray:

Cool greens
Warm buffs, yellows, and browns
Combined cool and warm colors
Dainty blue with yellow trim
Coral with black and metallic patterns.

No aspect of the environment for human beings better illustrates the complexity of psychological aspects than the color scheme. For the purpose of this discussion, let us extend our view to include several typical interiors besides those of the work world in its narrow sense, and consider the difference in the approach to the question of color scheme. In the schoolroom a wide range is permissible from an esthetic viewpoint. In general, the decorative schemes may be divided into "warm" and "cool" ones, the former for northern exposure and the latter for other exposures. Decorative details may be included within reason, but not to the extent of distraction. Walls should be considered to be backgrounds. As such, texture adds interest, but patterns generally violate the fundamental laws of simplicity and unobtrusiveness. Fortunately, consideration of cost and maintenance usually favors simplicity, and at this point it should be obvious that good taste costs no more than bad taste.

Colors for Factory Interiors and Machinery

In the hospital, glossy white reigned a long time, owing to a narrow efficiency viewpoint. A glossy paint is easily washed, and white not only suggests cleanliness but reveals the lack of it. Serious consideration of the psychological aspects immediately questions the desirability of a general use of white, either glossy or matte. It provides a strikingly unfamiliar, uninteresting, and

even ominous environment for the patients, and must also influence attendants unfavorably. In hospitals, nature is relied upon as an aid to getting well. The environment should bear some resemblance to that which is natural. This means the substitution of a reasonable degree of colorfulness for the unnatural whiteness. Exposure may be taken into account in varying the color scheme, but, in general, simplicity is also a ruling factor. The cool or warm color schemes are readily utilized, and even rich, warm grays afford a reasonable compromise.

The same influences which are expelling the white surroundings from hospitals are at work in the kitchens and bathrooms of homes. Here greater license is permissible because simplicity is not important excepting to those who prefer it to ornateness. To some extent greater, or rather more definite, license is permissible in a hospital exclusively for women. Here, delicate colors may be introduced in the furnishings without the slightest difficulty or danger of sound criticism.

In the general office there is no outstanding point of attack. Exposure, simplicity, maintenance, and lighting are all worthy of consideration in a color scheme. Much light should come from the ceiling. Perhaps the common extreme plainness of ceilings should be relieved by means of simple painted or molded patterns.

In the factory, considered solely as a work place, it appears that cool color schemes generally have more in their favor than warm ones. Years of experience in demonstrating the effects of lighting in a room with a neutral or colorless decorative scheme have adequately proved that there is a psychological influence upon the feeling of physical comfort. Such a room, indirectly illuminated with daylight lamps and flame-tint lamps, feels definitely cooler and warmer, respectively, regardless of what the thermometer indicates. Although light as a decorative medium has the great advantage of mobility in many interiors, this characteristic has little or no place in the decorative scheme of factories. Paint is quite practicable in the work world where the color scheme is to be "fixed."

In considering the environment in factories, the best color for the machinery or other equipment depends upon the area of the visual field occupied by it and upon the process involved. If the area is a large part of the visual field, certainly dark or vivid colors are undesirable. Owing to the tendency in modern art or craftsmanship toward the use of naked metals, aluminum paint may be used extensively where it is otherwise suitable. One objection is the high specular reflection which may reflect images of light sources causing glare from various directions, even if the lighting installation is otherwise satisfactory. The kind of dust in a factory is important. For example, where the cocoa bean is ground, there is bound to be much brownish dust. The machinery may be painted a color which would conceal this dust.

There are many factories or portions of them which are show places. It is quite legitimate to take this into account and an esthetic appeal be made to visitors, provided the worker is not entirely lost sight of. A reasonable enhancement of the color scheme is possible and justifiable without producing that which is unfavorable and distracting to the workers. Certainly much can be done along this line without producing sensational color schemes for publicity purposes.

In this new era of evolving and extending use of color, the entire gamut of satisfactoriness and appropriateness is likely to be encountered. Experience, knowledge, and motive of those responsible for color schemes will vary so much that the onlooker, who hopes to learn something useful in respect to proper environment in the work world, might well be wary. Light and color, also lighting and environment, are so intimately related that eventually they should be treated together. *The seeing specialist is bound to replace the lighting engineer in the evolution of present primitive lighting into lighting for seeing.* The seeing specialist who has an adequate background of knowledge and who is familiar with the intricacies of seeing, begins with excellent qualifications much more necessary than an intimate acquaintance with period styles and associated equipment of the interior decorator. Environment in the work world must be founded broadly upon utility—production, contentment, safety, and comfort of the worker. The interior decorator is not generally familiar with these aspects, nor experienced in the work-world environment.

Economic Value of a Pleasant Working Environment

But no matter by whom the proper environments are introduced into the work world, they are bound to come and to pay dividends to every one involved. Adequate and proper lighting, orderliness, cleanliness, pleasing color schemes, improved seeing, attitude, outlook, contentment! In many work places all these factors of modern civilization cannot be introduced. However, much improvement is possible everywhere, and in much of the work world pleasant environments are entirely practicable. If we are to fully capitalize our knowledge and resources, certainly we must produce environments eminently satisfactory to the emotional being, which is an important part of the worker. The beneficial results would be both tangible and intangible. Even if the worker produced only the same amount of work but with a lesser output of human energy—physical, nervous, and mental—the objective would be worth while. This should be an important ideal toward which to strive if, indeed, we are to have ideals at all. However, the work world is necessarily dominated by economics, and these remarks may appropriately conclude with an economic notation. In ideal environments it seems safe to assume that the worker will produce more with less expenditure of energy. If so, he goes home less tired. Instead of going to bed after dinner, perhaps he will engage in recreation. Usually this means spending. Haven't we added to the old economic idea of conservation of human resources a new theory of earning more and spending more?

How Coal Market Values Are Related to Steam-Plant Design and Operation

The Two Eastern Coal Markets—Effect of Coal Sizes on Cost of Energy—Relative Production of Various Sizes—Effect of Preferential Demand for Certain Coal Qualities on Cost of Energy—Distribution of Eastern Bituminous Production According to Volatile Content and Ash Fusing Point—Relative Grindability—Precautions Necessary in Appraising Plant Performance

By G. B. GOULD,[1] NEW YORK, N. Y.

THERE has been steady progress toward higher thermal efficiency of steam generating units for many years. It is important to remember, however, that higher efficiency is not an end in itself, but merely a means to an end. The objective is greater economy.

In the case of gaseous and liquid fuels, which either naturally are, or can be made, quite uniform in their chemical and physical characteristics, greater economy is practically synonymous with higher efficiency.

But in the case of coal, which provides two-thirds of our energy supply, one does not necessarily follow from the other at all, for the reason that coal is a mineral product which varies over a wide range of physical properties. Most of these physical characteristics are inherent, and some of them can be modified by methods of mining and preparation. Others, such as size, are artificially produced to conform to the varying requirements of steam generating plants.

These physical characteristics of coal are intimately related to the design, construction, and operation of steam plants in such a way that the solution of any particular problem requires a blend of engineering and economics. The varying physical requirements of the thousands of steam plants which have already been built and which are now operating, create a selective demand for coals having certain characteristics. The composite effect of this preferential demand from plants already built determines in many important respects the internal price structure within the coal market, irrespective of the general level of coal prices. And this internal price structure, caused by past engineering practice, is an important consideration in the direction and operation of plants already built and in the design and construction of projected plants.

[1] President, Fuel Engineering Company of New York. Mr. Gould was graduated from Yale in 1910 with the degree of A.B., and attended the University of Pennsylvania for one year, receiving the degree of M.A. Since 1911 he has been associated with the Fuel Engineering Company of New York, fuel and power engineers, giving special attention to the work of collecting and classifying data on the quality and character of coal, market conditions, prices and values, and the application of these data to the specific requirements of steam generating plants.

Contributed by the Fuels Division and presented at the Hartford, Conn., Meeting, June 1–3, 1931, of The American Society of Mechanical Engineers. Abridged.

The purpose of this paper is not to discuss the many details of design or operating methods, but to consider the economic pattern of an important section of the coal market as we find it today.

The Two Eastern Coal Markets

Here in Hartford we are approximately on the boundary between two distinct economic provinces, as far as the coal market is concerned. To the east lies an industrial section which secures its energy supply chiefly from the coal fields of southern West Virginia, whence it comes first by rail to tidewater, and is then transported by water to the various New England ports on the Atlantic and on the Sound, to be consumed there or be again shipped by rail inland. In this southern West Virginia area the annual production is close to 100 million tons, of which 12 to 15 million tons are shipped to New England.

To the west lies another industrial section, comprising the westerly part of New England, New York, New Jersey, Pennsylvania, Maryland, and northern West Virginia. Practically all of the coal consumed in this area is produced within its borders. Some 2000 bituminous mines and more than 200 anthracite breakers within this district produced 265 million tons in 1928, or 46 per cent of the total produced in the United States.

The consumer at any point in this area can, if he chooses, buy coal from a substantial proportion of these numerous mines. And he has an almost bewildering variety of coal qualities to choose from. This variety in the coals available ranges from the 5 per cent volatile anthracite to the 35 per cent volatile bituminous coal; the fusing point of the ash may be anywhere from 2000 to 3000 deg. fahr.; the heat value in normally merchantable grades may be as low as 11,500 B.t.u. or as high as 14,500; and the coal is prepared in an increasing assortment of sizes. There is no other important industrial section on this continent which can anywhere near equal this one for variety of coal characteristics. And consequently there is no other section of this country in which the successful conduct of steam generation demands such a thorough knowledge of coal market values.

Here is a section in which the interplay between plant

design and operation on the one hand, and the various physical characteristics of coal as distinct from its energy value on the other, can be seen at its best. Almost any time during the past year energy in the form of bituminous coal has been available at any point about midway between the mines and the outer boundaries of the district at prices ranging from 13 cents to 18 cents per million B.t.u. In other words, some consumers have bought a given amount of energy along with one set of coal characteristics, at a cost nearly 40 per cent above that paid by others for exactly the same amount of energy in a different kind of coal.

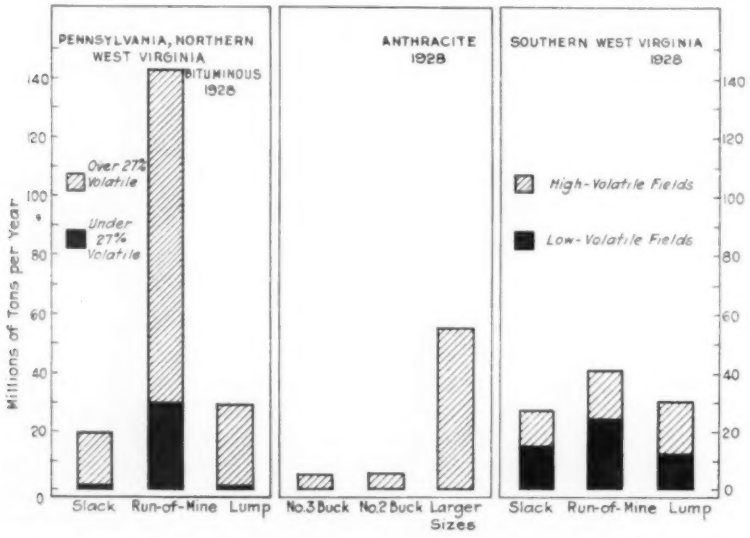


FIG. 1 DISTRIBUTION OF COAL PRODUCTION ACCORDING TO SIZES

It would be impossible to maintain such a spread in the cost of energy over a period of years without some compelling cause. Otherwise, those mines producing energy at 16, 17, and 18 cents per million B.t.u. would have been shut down, and all the business would now be in the hands of those which could produce it at 13, 14, or 15 cents. The cause, of course, is to be found in the limitations of the plants in which the coal is used, or in what their operators believe the limitations to be. In other words, at any given price level the relative prices of individual coals are determined more by their physical characteristics than by their energy value. The simplest and most obvious manifestation of this is found in the gradation of prices according to the *size* of the coal, with which every one is familiar.

EFFECT OF COAL SIZES ON THE COST OF ENERGY

Taken in their order, the lump coal which is used mainly in household and other small heating plants, and for certain industrial processes, brings the highest price per ton, and then follow the run-of-mine, nut and slack, and slack. At the mine, the lump coal in every bituminous field is sold at a price from two to three times that of slack. In the anthracite field the difference in price between the domestic sizes and the smallest steam size is still greater. The widest spread in energy value between the lump coal and the slack from a bituminous mine will be about 5 per cent. Frequently it is much less.

From a market standpoint, however, the difference in cost of energy must be based on the cost at the point of consumption, because of the preponderant effect of transportation costs. Applying a freight rate which is fairly typical for the Middle Atlantic territory ($2.76 a net ton) and expressing the cost of energy in a typical high-volatile slack coal as 100, the relative cost of energy in the other sizes may be generalized as follows:

Slack	100	Run of mine	115
Nut and slack	110	Lump	120

A similar comparison for the three small sizes of anthracite gives the following relationship:

No. 3 Buckwheat	100
No. 2 Buckwheat	110
No. 1 Buckwheat	130

These are differences in the cost of *energy*—not in cost per ton. They are due to methods of use and customs which have become established during the early evolution of coal-burning equipment.

These differences in the basic cost of energy in the form of coal which are related to gradations in size, are the result of the particular course which the evolution of coal-burning methods happens to have followed. This has an important bearing on what the engineering profession is doing and will do in the near future in the development of coal-burning equipment and in the design of steam generating plants.

An understanding of it helps to differentiate between fundamental differences in value and those which may be only temporary because based upon customs and methods of use which are changing. Under existing conditions there is a constant economic urge to find and apply methods of extracting an equal amount of useful energy from those forms of coal which provide the energy at the lowest cost. For the moment we are considering only those differentials due to size. In this connection it is interesting to inquire into the relative amounts of these sizes available.

RELATIVE AMOUNT OF VARIOUS SIZES OF COAL PRODUCED

Fig. 1 shows graphically the relative proportions of the different sizes of coal being produced in those coal fields which supply New England and the Middle Atlantic States.

Only a glance is needed to show what a relatively small proportion of slack is available from the Pennsylvania-Northern West Virginia field; about 20 million tons out of a total of 190 million. In the anthracite field there were shipped about 5 million tons each of No. 3 Buckwheat and No. 2 Buckwheat out of total

shipments of 66 million net tons in 1928. These small sizes of anthracite are in competition with bituminous coal.

It would seem from this that it would not take a very great shift in demand from the run-of-mine or lump to slack to practically equalize the cost of energy, as far as the difference between slack and run-of-mine coal is concerned.

Until recently slack has been produced only as a by-product resulting from the demand for the lump sizes. The steady increase in the use of coke, oil, and gas for domestic heating tends to diminish the supply of slack, while the economic advantage in using slack in large plants tends to increase the demand for it. In other words, what present economic advantage there is in using slack coal may very easily disappear within a comparatively short period of years, provided the present trend of demand continues. Somewhat the same situation exists in the case of anthracite, for the supply of No. 3 Buckwheat tends to be reduced by the same causes, although an increase in demand is held in check by the competition of bituminous coal. In the southern West Virginia fields, it will be noticed the proportionate amount of slack is much greater. It should be remembered that these two bituminous-producing areas are economically distinct as to the localities they serve, except as they compete along the boundaries of their natural markets.

Extension of the use of pulverized coal has introduced a new situation with respect to coal sizing. Mines in sections of the field where the coal does not lend itself to the production of screened lump coal, have begun to screen out of the run-of-mine, fines which pass through $^1/_4$-in., $^3/_8$-in., or $^1/_2$-in. screens for shipment to plants using pulverized coal. There is a double advantage in doing so. The fines are obviously suitable for pulverizer service, as far as size is concerned, and the remaining coal from which these fines have been excluded is a more desirable fuel for stoker use. Such advantage as there may be in a price differential favorable to these fines may be short lived, depending on how rapidly pulverized-coal burning is expanded. On the other hand, it may be prolonged by an increasing preferential demand from stoker-equipped plants for coal from which the fines have been excluded, thus increasing the supply of fines in advance of the demand for them for pulverizers.

Effect of Preferential Demand for Certain Coal Qualities on the Cost of Energy

Of even greater importance, and of considerably greater complexity are the other physical characteristics of coal, which are found in the greatest variety of combinations in the coal fields of Pennsylvania, Maryland, and northern West Virginia, which supply the Middle Atlantic States and the western portion of New England. Here we find that the composite effect of many individual preferences and many coals with varying combinations of qualities, has resulted in a very considerable, although by no means a very precise or uniform differentiation of values. The only way to see this is to sample the market.

For this purpose we took at random 80 coal offers, submitted to our clients and in turn by them to us, during a short time in the summer of 1930, when prices were relatively stable. The quality of each of these 80 coals was definitely established from the average of a series of our own laboratory tests on anywhere from 10 to more than 100 samples of actual shipments of each of these particular coals. Possible distortion due to variations in individual shipments or samples was thus avoided, as well as a similar distortion which might have

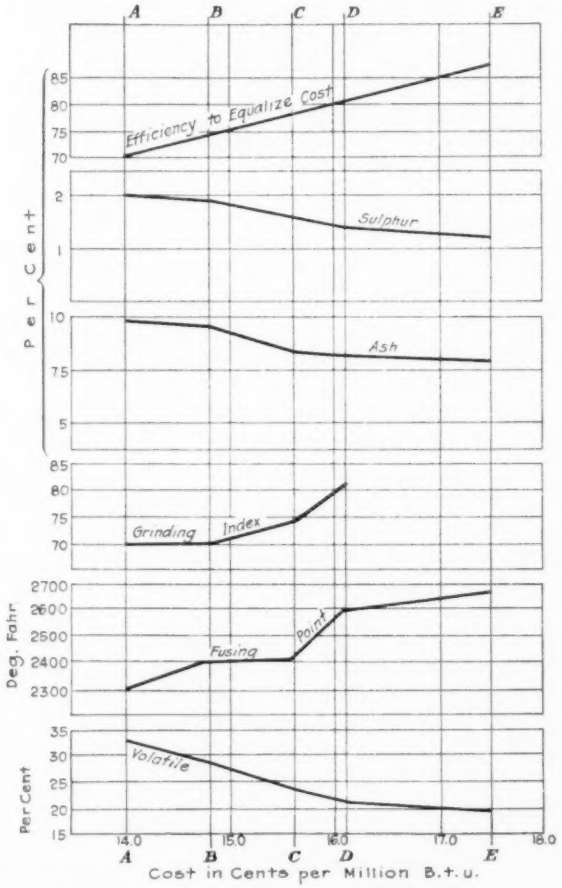


FIG. 2 RELATION OF COST PER MILLION B.T.U. TO COAL CHARACTERISTICS

been introduced if the comparison had been based upon producers' claims of quality. These 80 coals represent about 4 per cent of all the mines being operated in the section.

The average qualities and prices, including the freight rate to a representative point of consumption, were tabulated and then arranged in the order of the cost per million B.t.u. They were then divided into five groups, for each of which the various qualities and the cost per million B.t.u. were averaged. These group averages are shown graphically in Fig. 2.

It will be seen at once that as the average group cost per million B.t.u. rises from 14.0 cents to 17.5 cents (an

increase of 25 per cent) there is a steady progression toward lower volatile, higher fusing point, lower ash, lower sulphur, and a better grinding index. I hasten to explain that this coal market, when examined in detail, does not exhibit such a fine discrimination of values as might be inferred from this chart. The group averages in this case serve to reflect certain general trends of market preference, but they also conceal numerous individual inconsistencies in the market's appraisal of values. There are all the time in this market many peculiarly contradictory price and quality relationships which cannot be justified on any known engineering basis of appraisal.

For example, among these 80 coals, some having less than 20 per cent in volatile will be found not only in group E but also in the D and C groups, which latter show a somewhat higher average. And in all of these value groups except E there are individual coals having a volatile percentage above 27. Likewise, while the average fusing point for group D is 2600 deg. and for group A 2300 deg., there are individual coals in the former group which are rated below 2300 deg. and some in the latter group well above 2600 deg. Nor is it an uncommon thing for two coals practically identical in B.t.u. value, as well as in all the other measurable characteristics, to sell at prices which differ as much as 30 or 40 cents a ton, and sometimes more.

This situation is due to the fact that there are many coals and many scattered buyers, and that many of the latter, either from choice or necessity, employ rather inaccurate, not to say haphazard, methods of determining coal values. Any one who has to deal with fuel values must be constantly on his guard not to be misled as to actually attainable values in this coal market. It is very easy for carefully prepared engineering estimates having to do with coal values in this market to be thrown out of line by failure to distinguish between those values which are typical and those which are exceptional on either the high or the low side. The wisdom of making an investment in a steam plant running into hundreds of thousands of dollars may depend on this one point.

To return to the group averages, it will be noticed that as the cost per million B.t.u. rises, the average volatile drops rather sharply from 33 per cent to 24 per cent, and then more slowly to just under 20 per cent. The average ash percentage shows its principal decline between groups B and C, while the average fusing point rises a little over 100 deg. between groups A and B, shows practically no change between B and C, and then rises sharply between C and D. It is between these two groups, also, where the sharpest rise is observed in the grinding index. We do not happen to have determined the grinding index for any of the coals which compose Group E, probably for the reason that the suitability for pulverizer service of coals in this price class is only a matter of academic interest.

The general trend of coal-buying preference, illustrated by Fig. 2, shows that in spite of numerous individual inconsistencies in the market's appraisal of values, there are a sufficient number of coal buyers who have a distinct preference for one or more of these coal qualities to create and maintain price differentials of considerable magnitude which have no direct relation to the energy value of the fuel.

While it is true that in some individual cases these preferences are based upon faulty methods of appraising plant performance or coal values and in others are due to inadequate knowledge of the coal market, it is safe to assume that in the main the coal-buying preferences which are reflected in Fig. 2 could be traced back to causes inherent in the equipment, design, or operating conditions in the plants.

Coal limitations, even in a given plant, do not necessarily remain constant, because they are not only related to type of equipment and design but also to the load. There is going on constantly some shift of demand in both directions; in the new and best-designed plants to the type of coal which yields the most energy for a dollar, and in some of the old plants, because of increasing load requirements, to those types which yield less. An interesting example of this is found in one plant, with which we have been associated for the past 18 years, during which time it has passed through the whole cycle. At the beginning, the plant was using a low-fusing-point, high-volatile slack, which was cheap and plentiful then as now, and operating at as good efficiency as could be expected for plants of that period. Gradually the load built up, and along with it, of course, the combustion rate, until it reached a point where to continue to use coal of that type meant both lower efficiency and higher maintenance costs. The situation was met for the time being by selecting one of the few high-fusing-point coals which could be bought without paying an excessive premium for that one characteristic. Normal efficiency was restored, and the cost of steam was kept below what it would have been if the use of the original type of coal had been continued under the new load conditions. The basic cost of energy in the coal was of course higher, and so was the cost of steam, than under the original load conditions, but more steam was being generated with the same equipment. The unmistakable signal of impending obsolescence had nevertheless been given. When the next increase in load was projected, a wholly new steam plant was planned and erected. Since then this plant has been again using the same type of coal it started with years ago, but of course at much higher efficiency because of the advance in the whole art of steam generation which had been made in the interval.

Another experience which illustrates the shift of demand to less economic types of fuel is the case of a plant which started off with a severe fusing-point limitation due to improper design. It was a natural-draft plant, and as its load grew it was handicapped by a draft limitation as well. The immediate problem could only be solved by changing to a screened-nut size. This plant, too, has given the preliminary signs of obsolescence. Many similar cases are familiar to every one who has to do with steam generation.

DISTRIBUTION OF EASTERN BITUMINOUS PRODUCTION ACCORDING TO PERCENTAGE OF VOLATILE

The differences in value due to size and other characteristics must be taken into consideration by those who design steam plants and by those who invest money in them. The design of existing plants, which have been built at various times throughout the past thirty years, during which period our knowledge of such things has advanced considerably, is the fundamental cause of existing market preferences, which latter are reflected in the substantial premiums being paid for certain physical coal characteristics.

And both the plant designer and the maker of combustion equipment are concerned with the problem of

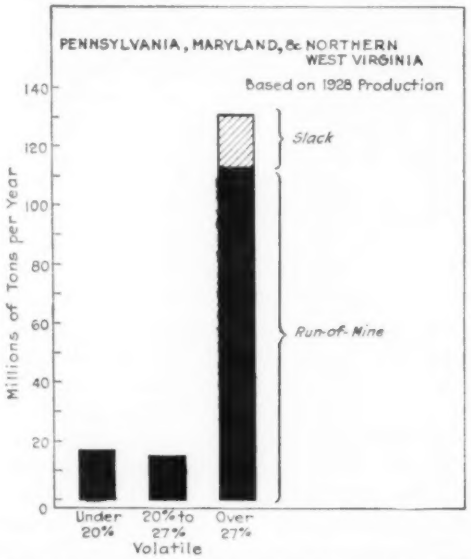


FIG. 3 DISTRIBUTION OF COAL PRODUCTION ACCORDING TO VOLATILE MATTER

creating plants which not only can successfully use those types of coal which at the moment yield the greatest energy per dollar, but which also are the most plentiful and thus most likely to provide the cheapest energy over a long period of time in the future.

Subdividing the production figures for the Pennsylvania-Maryland-northern West Virginia district, first into three classifications according to volatile, excluding that part of the output of each district shipped as screened lump, we arrive at a distribution of the tonnage as shown in Fig. 3. Approximately 10 per cent of the output has less than 20 per cent of volatile, another 10 per cent has between 20 and 27 per cent, while the remaining 80 per cent of the coal contains over 27 per cent of volatile. It now becomes clear why a market preference for low-volatile coal can become so definitely reflected in the cost of energy. By reference again to Fig. 2, it will be seen that the highest cost per million B.t.u. goes along with a group of coals which average just under 20 per cent in volatile. Groups D and C, falling midway in the scale of energy cost, are seen to average 21 per cent and 24 per cent, respectively, while Groups B and A exhibit still lower costs, with volatile averages of 29 per cent and 33 per cent.

While the lower-volatile coal is no doubt preferred in certain plants, and in certain localities to avoid objectionable smoke, the market preference reflected here is not wholly due to differences in volatile. It so happens that the lower volatile coals also frequently have other desirable characteristics, such as a higher fusing point of the ash. In this connection it will be noticed that there seems to be a more significant difference between groups E and D, or between D and C in fusing point than in volatile, or any of the other characteristics. On the other hand, the differences between groups C and B are more particularly in the percentage of ash and volatile, with practically no difference between them, on the average, in fusing point. Then fusing point and volatile again become the major points of distinction between the two lowest cost groups, B and A.

DISTRIBUTION OF PRODUCTION ACCORDING TO FUSING POINT OF ASH

Fig. 4 shows graphically our estimate of the distribution of tonnage according to fusing point, in combination with the estimates of production according to volatile and size (exclusive of that part of the total shipped as screened lump).

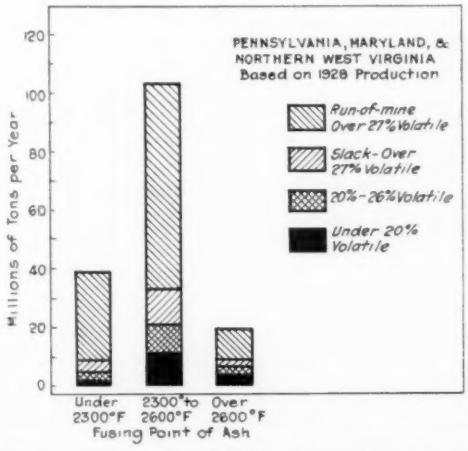


FIG. 4 DISTRIBUTION OF COAL PRODUCTION ACCORDING TO VOLATILE MATTER, FUSING POINT, AND SIZE

The chart very largely speaks for itself, but briefly summarizing one or two outstanding facts, it will be noticed that only 12 per cent of the total tonnage of all sizes here represented, and including the whole range of volatile, has a fusing point safely over 2600 deg. If two requirements are combined, such as less than 20 per cent volatile *and* over 2600 deg. fusing point, only 2 per cent of the total tonnage would qualify. And only half as much as that would qualify if it is desired to combine the economic advantage of a high-volatile slack coal with a fusing point above 2600 deg.

As far as the fusing point of the ash is concerned, the coals produced in the southern West Virginia area, taken as a whole, present somewhat fewer difficulties to the plant designer or operator than do the coals

which supply the Middle Atlantic States, for in that area, according to our records, about 46 per cent of the coals can be rated at above 2600 deg., an equal proportion between 2300 and 2600 deg., and only 7 per cent below 2300 deg.

GRINDING QUALITIES

As a result of the expansion in the use of pulverized coal there is another physical quality which must be considered, and that is the relative grindability of different coals. The precise effect of this difference among coals is not easy to define or measure, and its relative importance from an operating standpoint varies considerably between plants. In general, it is of course obvious that coals which pulverize most easily are most desirable for this type of service. While we have established a method of rating coals according to their grindability, our data are not yet sufficiently complete to serve as a reliable basis for tonnage estimates. The present indications, however, are that there will be found in this northeastern area a comparatively small tonnage which is exceptionally easy to pulverize, with an index above 80 on our scale, a similarly small tonnage which will be relatively hard to pulverize, with an index below 40, and the major part between these two points, the larger proportion of which will be nearer the lower figure.

NEED FOR SEPARATION OF EFFICIENCY AND COAL-QUALITY LIMITATIONS IN APPRAISING PLANT PERFORMANCE

From the foregoing facts and estimates, it is easy to see why, in this Middle Atlantic area particularly, a plant which is so designed and operated that it must have a coal with a high fusing point, or very low in volatile, or very easy to pulverize, or in the form of a screened lump, may be subject to a definite economic handicap in buying coal, which will be, of course, directly reflected in the cost of steam. And if several of these physical requirements are combined, the difficulties and penalties marketwise become very much greater. The handicap can be modified in its effect in individual cases by skilful selection of particular coals which offer exceptional values, and of which, at any given time, there are usually a very few in each quality classification, but severely limiting requirements as to coal quality are always a danger signal symptomatic of an economic handicap deserving careful investigation.

It might be said that those plants which are paying more for the energy than the best attainable values in the market, are compensating for this expenditure by securing higher boiler and furnace efficiency and lower operating costs.

But assuming that an individual plant does thus compensate by higher efficiency for the premium it pays for certain coal characteristics, it still remains true that the plant is economically handicapped, for today there are plants using coals which would fall in group A which are operating at practically the maximum efficiency so far attained.

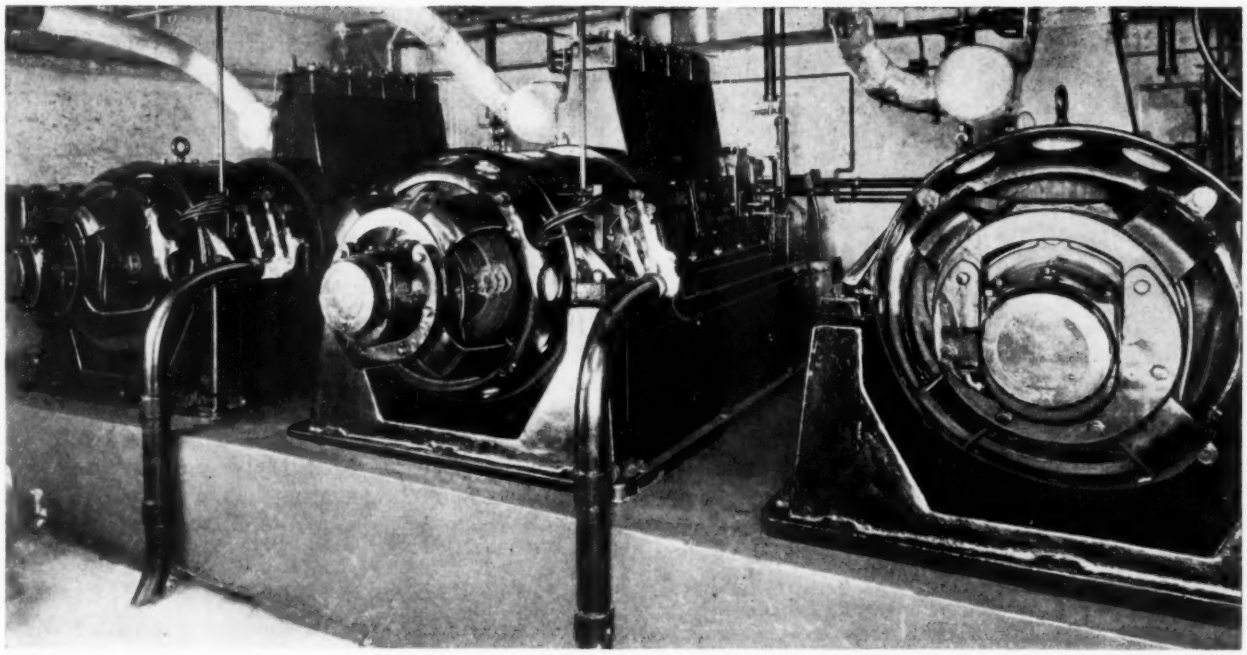
From the standpoint of plant operation, it is important to determine as accurately as possible what engineering limitations there actually are in a given plant, so that coal selection can be governed accordingly. Any limitation placed upon the coal buyer which is due to an incorrect diagnosis imposes exactly the same economic penalty on the plant as if the limitation actually existed.

Any premium, therefore, that is paid to secure certain physical characteristics in coal, deserves to be examined carefully to determine whether those qualities are in fact essential to best performance. These plant requirements are often exaggerated by being arrived at from observations of performance with several different coals, the exact characteristics of which are not determined, instead of analyzing the plant itself and then relating its characteristics to the market. If for one reason or another a plant is actually limited to a class of coals which bring a premium above their relative energy value, then that is a measure of obsolescence, which should be appraised by itself, distinct from a plant's efficiency limitations.

This is especially important in estimating the value of plant modernization, for a considerable part of the prospective return on the investment in a new plant may depend upon greater freedom in coal selection. The operating costs in the existing plant should be carefully analyzed in the light of the plant's real coal limitations with reference to market values. Too often the operating costs of the plant it is proposed to replace are used for comparison without analysis, and upon the assumption that whatever coal the plant has been using represents the best attainable values. This is by no means a safe assumption. And of course it is extremely important to accurately forecast what coal limitations the proposed plant will have, and what they will mean in terms of typical market values.

In view of the peculiarly intricate structure of the coal market, and the great diversity of physical qualities in coals which reach common points of consumption, in this eastern part of the country particularly, the description of a steam plant's performance to be complete should include specifically those coal characteristics found necessary under the operating conditions being reported. Coal-buying limitations in a given plant will of course vary with the load, because they are closely related to the rate of combustion or the rate of heat release. Summarizing our own experience in this respect, for each increase in the combustion rate of 4.5 lb. of coal per sq. ft. of grate per hour, the required fusing point rises 100 deg., other factors remaining constant.

If a plant's coal-buying limitations are not reported, the measure of efficiency, standing alone, provides no basis for appraising its true economic worth. On the other hand, if the plant's coal-buying limitations are accurately determined and reported, they can always be related to attainable coal market values, even at some later time when market conditions may be quite different.



AUTOMATIC DIESEL POWER PLANT IN HOTEL CHELSEA, NEW YORK, N. Y.

The Present Position of the Automatic Diesel-Electric Plant

Design, Equipment, and Operation of Multiple-Unit Diesel-Electric Power Plants in Which the Starting and Control of Engines and Electric Generators Is Effected Automatically in Accordance With Load Requirements

BY EDGAR J. KATES,[1] NEW YORK, N. Y

A WEIRD sensation awaits the engineer accustomed to ordinary power plants, when he opens the door of an interior basement room in a large city building and enters a complete power plant running by itself in total darkness. He hears the whirr of the engines and generators, and if he waits a while a few clicks of switches and changes in running pitch apprise him that generating units are being started or stopped in accordance with the load requirements.

Although automatic electric-generating units driven by gasoline engines, such as farm-lighting outfits, have been widely used for twenty years, the automatic multiple-unit Diesel-electric power plant for high-grade service is a novelty. Some information is given in this paper on the design and operating characteristics of such a type of plant.

The application of Diesel engines to automatic service is a natural evolution from the earlier gasoline-engine plants. The original small farm-lighting outfits led to the construction of larger units, some even being installed in small towns for furnishing electric service to the community. However, while the gasoline engine did the work satisfactorily, its fuel cost in the larger sizes was considerable. Consequently when the cost of gasoline rose from the low levels of 1914–1915 and high-tension electric power became available, these large plants lost much of their economic justification.

In the past few years the gradual refinement of the Diesel engine has made available engines that operate

[1] Consulting Engineer. Mem. A.S.M.E. Mr. Kates was graduated from Columbia University with the degrees of B.A. and M.E., and then was employed in the Diesel-engine department of the De La Vergne Machine Company. For eight years he was chief engineer. Subsequently he has been in independent professional practice in Diesel-engine design and power-plant work. He was for three years Lecturer on Diesel engines at the Polytechnic Institute of Brooklyn and was for five terms Chairman of the Oil and Gas Power Division, A.S.M.E.

Presented at the National Oil and Gas Power Meeting, University of Wisconsin, Madison, Wis., June 23–26, 1931, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Slightly abridged.

satisfactorily under automatic control. One such plant, based on the patents of Howard F. Carpenter, was installed in 1927 to serve the rural community surrounding the town of Seward, N. Y.[2] This 25-kw. plant did not employ multiple-unit operation, and while its voltage regulation met the local requirements it would not have been sufficiently precise for high-grade service, such as in a hotel or office building.

The low fuel cost of Diesel power has instigated the construction of larger automatic plants containing several units. Numerous problems are involved, such as the automatic starting and paralleling of the generating units, the equalizing of the load, and the control of line voltage to prevent flicker of lights on rapidly changing loads. In such plants a storage battery is considered essential, its main functions being to perfect the voltage regulation, to start the Diesel engines by motorizing their generators, and to provide emergency capacity.

The automatic Diesel plant installed in 1930 in the Hotel Chelsea, New York City, is based upon the patents and designs of C. F. Strong, whose efforts in this field go back to the early automatic gasoline-engine plants of 1912.

Method of Operation

This type of plant, which is the subject of the present paper, consists of several Diesel-electric generating units operating in parallel with a storage battery and a battery booster, all controlled entirely automatically. Diesel generating units are started and stopped in accordance with load requirements, line voltage is maintained constant without flicker regardless of load surges, and all of the supply services to the engines are fully controlled and safeguarded. The Diesel engines are started by supplying battery current to their generators, and the battery-booster regulation maintains constant voltage on the line during the starting operation. The battery and booster also absorb the line load surges, thus preventing flicker of lights.

The electrical controls have been refined in many ways to insure complete reliability of service. For instance, if one of the generating units should fail to start or should become inoperative after being put on the line, it is automatically disconnected from the line and another generating unit is started and put into service to replace it. At the same time, on account of the existence of emergency conditions, the strength of the load relays is altered so that one more generating unit is operated than would be normal for the given load, thus providing an ample surplus of power capacity. Furthermore the spare unit, when once started, continues to operate irrespective of the line load, until the unit in trouble has been taken care of and its relay has been manually reset. When any unit is disconnected from the circuit because of trouble a signal is automatically transmitted to a central office in order that immediate attention may be given.

The economic justification for automatic Diesel power plants is the low cost of fuel combined with low cost of attendance. By reducing the need for human supervision it becomes practical for a few specially qualified experts to give highly competent inspection at regular intervals to the equipment in a group of plants, and also to take care of any derangements signaled to the central office. This assures the plant's being continuously maintained in first-class condition. Such expert supervision and maintenance, if properly organized, will cost much less than the attendance in manually operated Diesel power plants. This applies particularly to plants smaller than about 500 kw. and plants requiring 24-hour service, as in such manually operated plants the attendance costs per kilowatt-hour are quite large. The fuel efficiency of small-size Diesel engines is almost as good as that of the larger sizes, and the reduced labor cost resulting from completely automatic control thus makes it possible to produce cheap power in plants of comparatively small output.

Applicability

Among suitable applications for automatic Diesel power plants may be mentioned:

1 Light and power service for large city buildings, such as office and loft buildings, institutions, department stores, hotels, clubs, and apartment houses.

2 Development of outlying sections by electric public utilities where the load at present is too light to justify the construction of transmission and distribution lines.

3 Reinforcement of heavily loaded transmission lines.

4 In combination with steam power plants where there is need for low-pressure steam for heating or process work and Diesel engines can be effectively used to improve the heat balance and reduce overall costs. In such plants the Diesel engines can be arranged to start automatically as soon as the process-steam demand falls off and causes a rise in the steam-engine back pressure.

5 Suburban and country estates where central-station service may be unavailable, costly, or unreliable.

6 Emergency service. In some industries, such as rayon, a power outage causes great losses because it interrupts important continuous processes. An automatic Diesel plant could be used which would start instantly when outside power service was interrupted. The laws of many states require that coal mines be provided with auxiliary power in case of emergency. This could well be provided by automatic Diesel plants.

7 Railroad water-pumping stations, which are often located in sections isolated from public-utility lines.

8 Many sections of the country are now being supplied with cheap natural gas. The same principles and methods now used in automatic Diesel plants can readily be applied to automatic gas-power plants.

Control of the Diesel Engines

To start, run, and stop a Diesel engine the following

[2] *Oil Engine Power*, Dec., 1927, p. 811.

services must be supplied: (*a*) starting, (*b*) lubrication, (*c*) fuel, (*d*) jacket water, (*e*) exhaust, (*f*) air, (*g*) load control, and (*h*) stopping. In the automatic system referred to, these services are controlled and safeguarded as follows:

(*a*) *Starting.* The engines are started by causing their generators to act as motors supplied with current from the storage battery through suitable resistances. When first turned over, the engine fuel pumps are out of service; as the speed increases, the fuel pumps are cut in with restricted delivery, and finally when the engine comes up to speed and the governor takes control, the fuel pumps are given full delivery. As soon as the generating unit is up to speed and its voltage equals that on the board, its main switches are automatically closed, and it immediately operates in parallel with the units already in service and divides the load equally with them. The entire starting operation, from the moment when starting current is first supplied until the unit is on the line and taking its share of the load, consumes the surprisingly short period of ten seconds. The start, though rapid, is gentle, as there are no heavy explosions, because the fuel-pump delivery is restricted until the engine has come up to speed. Furthermore the electric starting serves to avoid the chilling of the cylinders which accompanies compressed-air starting.

(*b*) *Lubrication.* The engines are equipped with complete pressure-lubricating systems, each engine having its own directly driven lubricating-oil pump. The lubricating-oil pressure is safeguarded by a pressure bellows provided with electric contacts which, if the pressure falls to a dangerous point, will cut out the fuel pumps and stop the engine. (When this or any other forced shutdown occurs, another unit is started up at once automatically.) When an engine is started it cannot fire until the lubricating-oil pressure has been built up; if the lubricating system is functioning correctly the pressure is built up during the few seconds it takes to accelerate the engine from rest up to half-speed.

(*c*) *Fuel.* For the sake of complete independence each engine has its own fuel-supply system all the way back to the main storage tank, a fuel transfer pump being mounted on each engine and directly driven by it. The transfer pump delivers oil to a gravity standpipe which supplies the engine injection pumps through an efficient and easily cleanable oil strainer. The excess oil delivered by the transfer pump overflows from the standpipe back to the main storage tank in the usual manner. The fuel supply is effectively safeguarded by joining the fuel overflows from the standpipes so that if one of the fuel-transfer pumps should fail, the overflows from the other engines would keep that engine supplied with fuel. See Fig. 1.

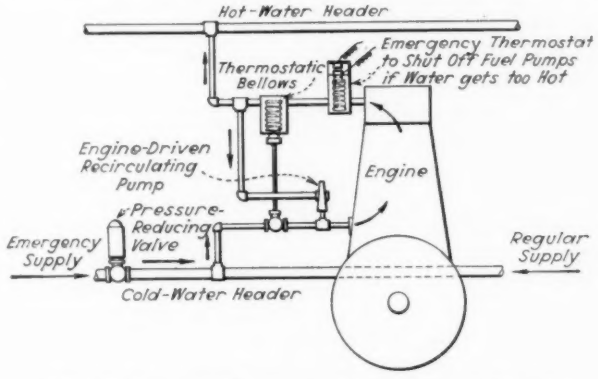


FIG. 2 SIMPLIFIED DIAGRAM OF JACKET-WATER SYSTEM

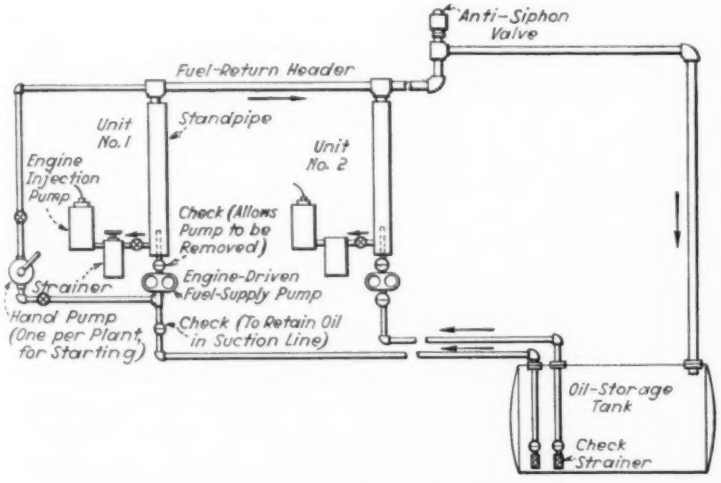


FIG. 1 SIMPLIFIED DIAGRAM OF FUEL-SUPPLY SYSTEM FOR AUTOMATIC DIESEL PLANT

(*d*) *Jacket Water.* The jacket-water system is illustrated in Fig. 2. The jacket-water discharge temperature is kept constant on each engine, independent of the inlet temperature and the load, by means of a thermostatic valve. In case of failure of the primary source of supply the reduced water pressure causes the emergency supply to be automatically fed in. A final safeguard is provided by a second thermostat arranged with electric contacts which will stop the engine if the water discharge temperature should rise dangerously high.

A large part of the jacket water is recirculated from the discharge back to the inlet by means of a pump directly driven by the engine. The capacity of this pump is such that with a water supply at 40 deg. fahr. and a discharge temperature of 140 deg. fahr. the temperature of the water entering the engine is 120 deg. fahr. This recirculating system is justified by the following benefits:

1 The temperatures of the various parts of the engine are much more uniform than would be the case if water at, say, 40 deg. fahr. were allowed to enter the engine directly. This reduces strains and distortions of the engine parts.

2 The flow through the engine jackets is much more vigorous, and prevents stagnation and vapor pockets which would result from less active flow.

3 The water passes through the engine so rapidly that there is no appreciable time lag of the thermostatic valve. (The bellows is immersed in the discharge water while the valve proper is located in the inlet pipe.)

4 The recirculating system makes it practicable to eliminate the bypass connection that is generally required around thermostatic valves.

5 On account of the vigorous flow and the elimination of vapor pockets, the jacket water may be safely discharged at a higher temperature. This reduces the amount of water required, improves the engine combustion efficiency, and also furnishes hotter water wherever this can be utilized to advantage.

(*e*) *Exhaust.* A common exhaust line for all of the Diesel engines in one plant is desirable in order to save space and expense. It also provides surplus exhaust-line capacity for the running engines whenever one or more engines are idle. As usually arranged, however, a common exhaust line has the fault that the exhaust from the running engines backs up into the idle units, tending to cause corrosion and also interfering with maintenance work. In the automatic system referred to, a common exhaust is used, but these disadvantages are avoided by providing an automatic valve in the exhaust pipe leading from each engine to the common manifold.

(*f*) *Air.* The engines obtain their combustion air directly from the engine room, which in turn is supplied from the outside through a fan and duct system provided with an air filter, the fan motor being arranged for variable-speed operation. In this way the engine room is cooled and ventilated, and clean air for combustion is supplied to the engine air intakes.

(*g*) *Load Control.* In manually operated Diesel power plants the engines generally carry widely variable loads and are sometimes even overloaded. In the automatic system the load on each engine is maintained by electrical means within the desired range for best performance, which has been found to be between 40 per cent and 100 per cent of rating. When the load becomes less, one unit is stopped, thus increasing the load on the others. When the load exceeds the desired maximum another unit is put in service, the extra load meanwhile being carried by the storage battery. The latter also takes care of momentary load surges whose duration is too short to justify the starting of another generating unit. The action of the load-control relays is very effective, and entirely prevents the imposition of overloads on the engines.

(*h*) *Stopping.* In the automatic system, engines are stopped in the usual manner by stopping the delivery of fuel by the injection pumps to the nozzles, utilizing the same control mechanism as is employed for the starting operation.

PERFORMANCE

The automatic Diesel installation in the Hotel Chelsea, embodying the controls and safeguards just described, is shown at the beginning of the paper. In future plants it is intended to recover the waste heat from the Diesel engines, but that was not done in this instance because the engines used require cool water jackets, and being of the two-stroke-cycle type, also have comparatively low exhaust temperatures.

Because of the continuous, accurate control and the many safeguards against trouble, the Diesel engines in an automatic plant operate under conditions far superior to those encountered in almost all other classes of service. These improved operating conditions, combined with expert supervision and maintenance, are expected to result in better performance and lower operating cost than in manually controlled plants. Sufficient time, however, has not elapsed to confirm these expectations by actual results, with the exception of one item, the engine fuel efficiency. That this has been definitely improved by the excellent operating conditions is shown by the fact that in the Hotel Chelsea installation the net plant output over a period of several months has been better than $10^1/_2$ kw-hr. per gallon of fuel from an installation of three $5^1/_2$-in. $\times$ $9^3/_4$-in., 500-r.p.m., two-cycle engines, operating 24 hours a day, supplying a heavily fluctuating electric load.

INFLUENCE ON ENGINE DESIGN

It seems likely that when the demand for Diesel engines for automatic service becomes sufficiently large it will be worth while for manufacturers to modify their designs to take advantage of the unusual operating conditions.

In the first place, the usual air starting equipment is entirely unnecessary, making possible the simplification of the cylinder-head design and also of the camshaft. At the same time the engine cost is reduced by the elimination of all air piping, valves, tanks, and compressors.

The fuel-injection system and the governor can be of the simplest type for constant-speed operation. As the engine never runs at light loads or idling, no provision need be made for good combustion under those conditions. No adjustments are required on the governor while the engine is in motion, for the purpose of paralleling, or for regulating load or voltage, thus further simplifying the governor mechanism.

It is not necessary to provide enclosures for valve gear, pumps, etc., inasmuch as the engines operate in closed engine rooms supplied with filtered air, and it is desirable that all parts shall be quickly accessible for inspection by expert supervisors. In such plants, enclosures for the sake of appearance are only a minor consideration.

Should the field of application for automatic Diesel power plants become as broad as the economics seems to justify, the large number of engines that would be required would make quantity production feasible along the lines so successfully followed in the automotive industry but up to now impracticable with Diesel engines. This would, of course, result in radical changes in structural design in order to facilitate mass production.

Water-Recovery Apparatus for Airships

Maintaining Equilibrium of Weight and Buoyancy of an Airship by Recovering Water From Engine Exhaust to Compensate for Weight of Fuel Burned—Desirable Features and Recent Developments in Ballast Collectors

By C. P. BURGESS,[1] WASHINGTON, D. C.

THE gross weight of an airship burning liquid fuel, and having no means of acquiring ballast during flight, is progressively reduced by the weight of the fuel consumed. In order to fly efficiently, and to make landings, an airship must be maintained in an approximate equilibrium of weight and buoyancy. Prior to the use of helium in American airships, it was the custom to maintain static equilibrium by valving the lifting gas to the outside atmosphere as required to compensate for the progressive diminution of the load carried. The lifting gas, hydrogen, being comparatively cheap, this method of operation was practicable although not entirely satisfactory. The introduction of helium, which was at first very expensive and obtainable only in severely limited quantities, made it imperative to find some means of compensating for the weight of fuel consumed without valving helium.

The possible methods of maintaining static equilibrium without loss of lifting gas may be classified as follows:

- *a* Condensing and recovering from the exhaust gases the water formed by combustion of the hydrogen contained in the fuel
- *b* Taking water from the atmosphere by means of a hygroscopic material such as calcium oxide
- *c* Lifting water from the sea or other bodies of water on the surface of the earth
- *d* Burning a gaseous fuel of approximately atmospheric density, instead of liquid fuel
- *e* Burning hydrogen in combination with liquid fuel in the proper proportions to maintain equilibrium of weight and buoyancy.

All of these methods have actually been tried in airships, although not always in conjunction with helium as the lifting gas.

Maintaining Equilibrium by Recovery of Water From the Engine Exhaust

When 100 lb. of ordinary aviation gasoline is burned, about 135 lb. of water is produced; and of this 135 lb., eight-ninths, or 120 lb., consists of oxygen taken from the air, and only 15 lb. is hydrogen contained in the original 100 lb. of fuel. Besides its convenience for maintaining equilibrium without loss of buoyant gas, recovered water ballast has other important advantages. The most valuable one is the great gain in safety resulting from having a large amount of ballast available to drop in case of loss of gas from damage to the cells when the ship is far from her base or destination. The extra ballast may also prevent disaster when landing; and it permits fuel or other loads to be taken aboard the airship at an intermediate or emergency landing in exchange for ballast, without any addition of buoyant gas, which might not be readily obtainable.

A disadvantage of the exclusive use of water recovery for maintaining static equilibrium is that the maximum altitude which can be reached on a voyage, without valving helium, is limited by the percentage fullness of the gas cells at the start of the voyage. In order to overcome this difficulty, it has been proposed to use small fuel-gas cells which would be filled at the start of a long voyage and would occupy the space which must be provided to allow for the expansion of the helium in order to rise to any desired altitude. The fuel gas would first be consumed without recovery of ballast; and after that the liquid fuel would be used in conjunction with the recovery apparatus.

The term "water-recovery apparatus," which has hitherto been used, is extremely cumbersome. "Ballast collector," it is believed, is better.

The process of cooling the gases and condensing the water vapor may be carried out continuously in one apparatus, or separated into two or more stages. The exhaust gases issue from the engine at temperatures between 650 and 750 deg. cent., which is above the melting point of aluminum. These very hot gases must be conducted through steel pipes until the temperature is reduced to about 500 deg. cent. before they can safely be injected into a cooling element constructed of aluminum.

From 500 to 53 deg. cent. no condensation of the water vapor occurs, and if this stage of the ballast collector is separated from the primary cooler it may appropriately be called the "secondary cooler."

From about 53 deg. cent. to the final minimum temperature of perhaps 35 deg. cent., the water vapor is condensed, so that the part of the apparatus working within that temperature range is actually the condensing element, and may be called the "condenser."

[1] Bureau of Aeronautics, Navy Department. Mr. Burgess was born in Boston, Mass., April 9, 1888. He studied naval architecture at the University of Glasgow, Scotland, graduating in 1910. He entered the U. S. Navy Department during the war, and specialized in airship design, which at that time was a new art in the United States, almost without scientific basis. His book on "Airship Design" is recognized as the standard work on its subject.

Extracts from a paper presented at the Fifth National Meeting of the A.S.M.E. Aeronautic Division, Baltimore, Md., May 12 to 14, 1931.

There are, of course, no sharply defined points in the passage of the gases through the ballast collector at which the various temperatures mentioned in the foregoing definitions are reached.

The condensed water is carried along by the exhaust gas in the form of spray, which must be separated from the gas if it is not to be lost. The separator most commonly used consists of an aluminum box containing baffle plates between which the exhaust gas passes in an irregular course. The efficiency of this type of collector depends to a very great extent on the velocity of the gas through it. A velocity of about 600 ft. per min. has proved most satisfactory.

Recently a rotary centrifugal type of separator known as the "Hagan separator" has been tried out with encouraging results.

Desirable Features in a Ballast Collector

The ideal ballast collector should have the following characteristics:

- *a* One hundred per cent recovery of water under average operating conditions
- *b* Low air resistance
- *c* Light weight
- *d* Small back pressure
- *e* Easily cleaned from deposits of oil and soot
- *f* Compactness and ruggedness
- *g* Freedom from freezing in winter.

Low air resistance is obviously of prime importance. Since a certain amount of area is necessary, the goal to be sought by the designer is an apparatus having no more resistance than the frictional resistance of its surface. The ultimate ideal is to use the surface of the hull for the cooling area, so that there will be no net resistance at all due to the collector; but there is enormous room for improvement without going to that ultimate refinement. The apparatus used on the U.S.S. *Los Angeles* at the present time has about fifteen times more resistance than the skin friction of an equal surface.

Tubes running in an approximately longitudinal direction have very little resistance except skin friction; but they must be connected by headers, and unless these are carefully designed, their air resistance may be large. One solution is to place the headers within the hull; but that is likely to involve structural difficulties, and may cause overheating of the headers. If longitudinal tubes are used, they must not be so clustered together that they obstruct the flow of air between them. They must also be supported at close intervals in order to avoid deformation by the heat and vibration.

Placing the tubes with their longitudinal axes at right angles to the air flow facilitates obtaining an apparatus which is strong and compact, with headers and supports presenting little resistance, but having very great resistance from the tubes if their cross-sections are circular.

Transverse tubes may be flattened and placed so as to present substantially flat surfaces parallel to the air flow. There is at present no experimental evidence to show whether or not tubes may be safely flattened in this manner without encountering the troubles which arise whenever an attempt is made to use flat plates in a ballast collector.

For average speed and operating conditions in modern rigid-airship practice, about 1.5 sq. ft. of cooling surface per horsepower is required for the ballast collectors. Assuming that 1-in.-diameter aluminum tubes with a wall thickness of 0.02 in. are used, the weight of the tubes is 0.29 lb. per sq. ft., or 0.435 lb. per hp. The total weight of the collector is fully two or three times greater, depending upon the design of the headers, supports, etc. In order to avoid the troubles resulting from the use of flat plates, it seems necessary to have aluminum castings for the headers.

The prevention of freezing of ballast collectors has been accomplished in the *Los Angeles* by closing the sides of the collector with a fabric curtain, and placing ordinary radiator shutters over the front face. Such an arrangement is permissible in an apparatus which already has nearly as much air resistance as a flat plate of the same frontal area; but it would completely spoil the advantages of the low-resistance types which it is hoped to develop.

Recent Developments in Ballast Collectors

A novel type of ballast collector is contemplated for the new 6,500,000-cu. ft. airship *Akron*, now under construction for the U. S. Navy. The collector consists of 14 banks of longitudinal tubes about 8 ft. in length, having elliptical cross-sections and placed close against the hull of the airship. The ends of the tubes fit over elbows which are welded to headers inside the ship. These headers connect the successive banks of tubes, and being inside the hull, add nothing to the ship's air resistance. The apparatus should have a high rate of cooling in proportion to its surface area; and the air resistance will be very low. The chief difficulties to be overcome are mechanical, since welds and flat surfaces are involved, and these features have hitherto proved stumbling blocks in other ballast collectors.

A very simple ballast collector is being constructed for trial on the U.S.S. *Los Angeles*. It comprises four rows of aluminum tubes, 3 in. in diameter by 0.025 in. wall thickness, extending aft and upward along the side of the ship for a length of 50 ft., and then turning forward and down for an equal distance. The tubes are inclined at about 10 deg. to the longitudinal meridian lines of the ship. At this angle their air resistance is but slightly greater than that of longitudinal tubes and is only about 2 per cent as much as transverse tubes. Their comparatively large diameter, 3 in. instead of the usual 1 in., tends to reduce their cooling efficiency, but this is compensated by higher gas velocity, which is considered to be permissible because the directness of the gas passages should more than offset the effect of the increased velocity in building up the back pressure.

Survey of Engineering Progress

A Review of Attainment in Mechanical Engineering and Related Fields

CORROSION

Protection of Metal by a Lead Film

THIS process has been developed by the Bullard Company, of Bridgeport, Conn., in connection with the manufacture of bumpers for automobiles. Bumpers cannot be polished rapidly and economically unless the heat scale is first removed completely from the surface to be polished, and the composition of the steel bars used for bumpers is such that the heat treatment covers the bars with a hard, black magnetic scale, in addition to which rust is apt to be present. Pickling, sand rolling, and sand blasting were tried without giving satisfaction. The so-called Bullard-Dunn process was then adopted, and it is described in the present article.

The process itself is simple and inexpensive. Parts to be cleaned are first freed from grease or oil, if necessary, using any suitable method of grease removal. They may then be hung on hooks from a copper bar extending across the tank top, this bar being connected with the negative pole of a direct-current generator. Thus the work is a cathode; the anodes are usually lead plates. (Appropriate changes would be made in the set-up for cleaning small parts in a barrel.) The solution is maintained at a temperature of 150 to 170 deg. fahr. and is a sulphate-chloride bath.

Immediately the iron forging or other article to be descaled is immersed, hydrogen gas is generated by electrolysis of the water content of the solution, and forms between the scale and the metal surface beneath.

A small but effective amount of lead is in the solution, and a microscopically thin film is deposited on the base metal itself immediately it becomes exposed. This film not only prevents any attack on the iron, but also effectually prevents the absorption of any hydrogen into the intercrystalline cement between metallic grains. Thus the possibility of hydrogen embrittlement is avoided.

Furthermore, since lead will not deposit on lead itself in the electrolyte used, prolonged immersion in the bath does not increase the thickness of the adherent film on the areas which were first cleaned, but merely results in the deposition of a lead sponge or powder, which is removed by rinsing. The lead film will not interfere with machining or drawing operations, nor will it clog grinding or polishing wheels.

Where metals are cleaned prior to welding or electroplating with other metals, or where it is advisable to avoid even a trace of contamination, as, for example, in hot galvanizing or hot tinning, the lead deposit can be removed quickly and completely by treating the metal anodically in an alkaline bath maintained at 200 deg. fahr. In this defilming treatment there is no action on the ferrous metal itself. It is claimed that this process has given very satisfactory results. It has been applied also in gear manufacturing. It is claimed that hardening cracks and other defects are rendered visible, and that bottom areas of recesses may be cleaned as thoroughly as are the top or more exposed surfaces; dimensions are preserved absolutely. (E. T. Youd, Chief Metallurgist, The Bullard Company, in *Metal Progress*, May, 1931, pp. 56–59, 4 figs., *d*)

ENGINEERING MATERIALS

Some Recent Engineering Applications of Rubber

ONLY a brief abstract can be given of this interesting article. The author mentions the use of rubber bearings. Special bearings have been designed for the commonly recommended temperature of 150 deg. fahr. for places where loads are not excessive and where it is possible to work out a satisfactory holding device for the special type of bearing required. Rubber bearings are not serviceable in contact with alloys.

Cutter-head and ladder bearings on suction dredges, which are subject to rapid wear and heavy strains, have been replaced by rubber without increasing the bearing size. Vertical guide bearings of tremendous sizes are used in hydraulic turbines. Bearings 2 ft. in diameter and 6 ft. long are not unusual. Rubber bearings in this service have given years of continuous operation.

In centrifugal sand pumps rubber bearings were in perfect condition after 14,000 tons of fine sand had been handled, while babbitt and bronze bearings previously used required replacement after an average of 4000 tons. Recently a rubber casing guard has been developed for use on rotary drill pipe in the petroleum industry. In this case the bearing is attached to the shaft. The authors refer to the anode process of electrodeposition of rubber from latex or other aqueous rubber dispersions. This permits laying down uniform coatings of soft, semi-hard, and hard rubber compositions upon articles of intricate shape by a single simple operation. The thickness of the coatings thus produced may be readily varied between 0.008 and 0.125 in. The tensile strength of vulcanized soft-rubber compositions is usually well in excess of 4500 lb. per sq. in., with ultimate elongation in the neighborhood of 90 per cent.

Among examples of absorption of vibration and noise the authors cite the uses of rubber-to-steel mountings in automobiles, in particular rubber-to-metal plates used as crankshaft-vibration dampers to reduce torsional vibration. Pressed between two steel sleeves rubber has now replaced lubricated spring shackles on some makes of automobiles. The same principle is being applied to treads of caterpillar tractors in an effort to eliminate bearing pins. The railroads are now applying rubber at the ends of elliptical springs, at the tops and bottoms of coil springs, over equalizer bars and journals, and at the center plates of trucks. Rubber packing rings are now made to resist successfully the deteriorating action of condensates, and air hose is available for pneumatic tools which is capable of withstanding the action of hot lubricating oil under high pulsating air pressures.

Braided-metal-jacket grease-gun hose, embodying the flexibility of an oil-resistant rubber compound, has a bursting strength of 10,000 to 12,000 lb. per sq. in. and operates under working pressures in the neighborhood of 6000 lb. per sq. in.

The rubber compounds used in conveyor belts have been immensely improved in regard to heat resistance. Rubber-covered conveyor belts are successfully handling hot cement, sand, limestone, and coke.

Despite such improvements in the resistance of rubber to service in contact with its natural enemies, heat and oil, there is a great deal yet to be desired. Rubber manufacturers and

their technologists are keenly competing for leadership in this field, a condition which assures further advances.

Self-healing cutting blocks embodying thermoprene as a binder are successfully replacing the maple blocks used under clicking machines for cutting out leather shoe and glove parts. The thermoprene blocks have a longer useful life than wood blocks and show less tendency to chip. Worn blocks can readily be reworked, since the binder is thermoplastic.

The comparatively recent seamless, laminated, flat belt construction, in which folded edges are eliminated, and which utilizes in the rubber the latest advances in compounding technic, enabling the use of a close-woven hard duck without danger of ply separation, has resulted in greater flexibility and longer belt life in power-transmission and conveyor service. Transmission belts deliyering greater horsepower with less slip and practically no stretch are thus produced. Conveyor belts made with this construction embody also a new method for securing the rubber cover at the edges of the belt. A striking example of the type of service in which such belts are performing is the case of a high-speed loading belt used to distribute coal in the hold of a vessel. Coal from an inclined conveyor drops vertically 60 ft., striking this horizontal loading belt, which travels at a speed of 4500 ft. per min. and handles up to 2260 tons of coal per hr. (J. R. Hoover and F. L. Haushalter, The B. F. Goodrich Co., Akron, Ohio in *Industrial and Engineering Chemistry*, vol. 23, no. 5, May 1, 1931, pp. 462–469, 19 figs., *g*)

A Formula for Creep

THE following formula is proposed to express creep or strain per unit time.

$$C = k \frac{(p - a)^3}{(b - p)^3}$$

where C = creep, p = tensile stress, and k, a, and b are constants which depend upon temperature. The formula is an experimental one, and according to it secondary creep becomes infinite when $p = b$, and zero when $p = a$. The formula if true implies that there is a definite limiting creep stress a, and the fact that it agrees with experiments affords evidence that such a limiting creep stress actually exists. Dimensionally the formula is correct if k is taken as the reciprocal of a quantity which is akin to viscosity. The author has determined k, a, and b for a nickel-chrome steel for temperatures from 300 to 600 deg. cent., and has plotted curves giving the experimental points and the curve according to the formula. (A. G. Hinton in *The Engineer*, vol. 151, no. 3930, May 8, 1931, p. 506, 2 figs., *eA*)

FUELS AND FIRING

Mechanism of Combustion of Powdered Coal

DEPENDING on their nature, bituminous coals, lignites, and anthracites pulverized into particles the dimensions of which are of the order of a few scores of micromillimeters (1 micromillimeter = $^1/_{25,000}$ in.), and the humidity of which has been reduced to about 1 per cent, ignite at characteristic temperatures varying from 700 to as high as 900 deg. cent. (1292 to 1652 deg. fahr.). These temperatures correspond fairly well to those at which the maximum development of hydrogen takes place during dry fractional distillation, such as has been carried out by Lebeau (7th Congress of Industrial Chemistry, 19, no. 4 bis, April, 1928, pp. 73–90, French section) on very small masses, namely, 0.5 to 1 gr., and it is precisely this that renders these measurements directly applicable to the first phase of combustion of powdered coal. This coincidence gives added strength to the author's idea that ignition of the coal in the presence of traces of water vapor starts by the combustion of hydrogen which is generated at the exit from the burner in the combustion chambers of furnaces. The carbonization, which is not instantaneous, evidently takes place during the first part of the travel of the luminous flame. The author estimates that the concomitant progressive oxidation due to the primary air (which represents, for example, 25 per cent of the combustive power, which is the quantity of air theoretically necessary for the complete burning up of a combustible material, as referred to in *Comptes Rendus*, vol. 174, 1922, p 1285), followed by gradual additions of the secondary air, affects first of all the hydrogen which produces ignition, and then the carbon, which (certainly at the beginning) is transformed into carbon monoxide. When the coke has been formed to a sufficient extent and become incandescent it decomposes the hygroscopic water and the water of formation, giving a "water gas of high temperature" ($CO + H_2$) mixed with a water gas of low temperature ($CO_2 + 2H_2$). The air introduced gradually

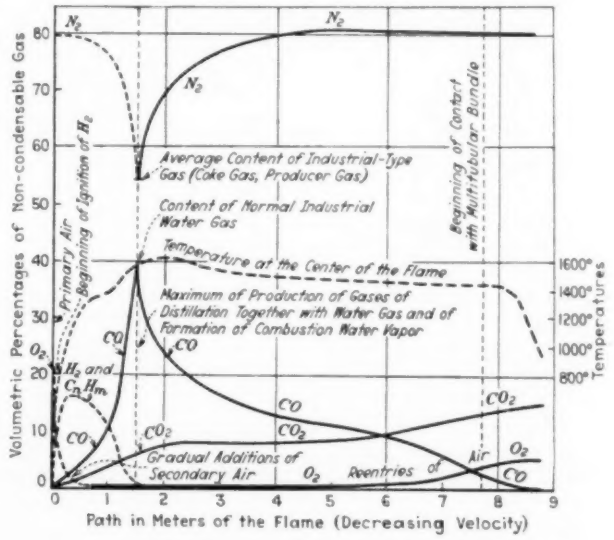

Volumetric Percentages of Non-condensable Gas
Temperatures
Path in Meters of the Flame (Decreasing Velocity)
Average Content of Industrial-Type Gas (Coke Gas, Producer Gas)
Content of Normal Industrial Water Gas
Temperature at the Center of the Flame
Maximum of Production of Gases of Distillation Together with Water Gas and of Formation of Combustion Water Vapor
Primary Air
Beginning of Ignition of H2
Beginning of Contact with Multitubular Bundle
Gradual Additions of Secondary Air
Reentries of Air
N2
CO2
CO
O2
H2 and CnHm

FIG. 1 GRAPHS SHOWING THE COURSE OF COMBUSTION OF PULVERIZED COAL

until its amount reaches about 120 per cent of that necessary for combustion, produces first, with the coke at a fairly high temperature, an air gas ($CO_2 + 2N_2$), and finally gives more and more of smoke ($CO_2 + 4N_2$). When the flame ceases to be luminous and reducing the combustion is complete, and when the content of N_2 attains its maximum and stays there, the CO_2 comes to predominate over the CO, which latter disappears completely in the presence of a small excess of air.

The author's conception differs materially from the theory of "maturation for combustion" of Aufhäuser ("Breanstoff und Verbrennung," Berlin, 1926), who assumes an intermediary formation of a water gas which is really mixed with a good deal of N_2, CO_2, and water vapor. It finds clear support in recent analyses of non-condensable gases taken at various points on the periphery of the pulverized-coal flame. The results of these volumetric analyses are given in a treatise by Fink ("Le chauffage des chaudières au charbon pulverisé," Paris, 1930, p. 87) in the form of a table from which the graph of Fig. 1 has been compiled. In this graph the dotted lines indicate the proportion of gaseous products of distillation which have not been measured by the experimenters and have been evaluated by the author.

Extending as one might say into both space and time, the phenomena of pyrogenation and oxidation of pulverized coal are easy to follow in the course of their development. One finds,

without any doubt in the opinion of the author, that carbon monoxide is formed first, which is contrary to the still generally prevailing opinion that primary oxidation is complete and results in the production of carbon dioxide.

The author believes, however, that it would be still desirable to make tests under perfectly controlled conditions of taking samples of gas and analyzing them, the latter procedure including the determination of the amount of hydrocarbons and hydrogen present in the flame. (R. A. Grebel in *Comptes Rendus des Séances de l'Académie des Sciences*, vol. 192, no. 9, Mar. 2, 1931, pp. 567–569, 1 fig., *t*)

HYDRAULIC ENGINEERING

Performance of Kaplan Turbines at Reduced Loadings

THE article here under consideration deals with the performance of the Kaplan automatic adjustable-blade unit installed in the Lake Walk Hydro Station of the Central Power and Light Company, San Antonio, Texas.

The Lake Walk plant is the lower of two hydro stations on Devils River. Because of the necessity for condensing water at a 20,000-kw. steam station farther downstream, this plant must operate practically continuously. The upper hydro plant—at Devils Lake—is under no such rigid requirement and may operate, within obvious limits, only during periods when accumulated water allows efficient loading. This plant contains a fixed-blade unit which has not the sustained efficiency of the Kaplan turbine at lower loads.

The operating record given in this article shows the mean average stream flows of the river and the energy production of the two plants for the months of 1929 and 1930. It also shows the total hours of operation of each plant. From the figures of total production and operating hours are derived the average loads of the two plants, which show the much lower loading of the Kaplan unit. At this average load the unit has an efficiency of 89 per cent. A fixed-blade turbine has an efficiency of only 79 per cent at this load. The difference between the two efficiencies indicates the saving of energy, which, as stated, amounted in 1930 to 563,000 kw-hr.

The original article contains a comparison of fixed-blade and adjustable-blade turbine operation month by month in 1929 and 1930. From this it would appear that the fixed-blade turbine operated 66 per cent of the time during 1930, while the adjustable-blade unit operated 97 per cent of the time. (C. L. Dowell in *Electrical World*, vol. 97, no. 17, Apr. 25, 1931, pp. 766–767, 2 figs., *c*)

INTERNAL-COMBUSTION ENGINEERING

A Dual Compression Precombustion Chamber

THIS engine was developed by R. A. Lister and Co., Ltd., and is now being distributed on the American market. Its salient feature consists of a two-part combustion chamber and a device claimed to facilitate starting by temporarily raising compression. As the flat top of the piston approaches within a few thirty-seconds of the flat undersurface of the cylinder head, practically 100 per cent of the clearance space in the dead-center position is made up of the two chambers and the channel that connects the larger one to the cylinder space. Both chambers are approximately spherical in contour, and fuel is injected into the larger one. The chambers are at least partially made up of massive inserted linings having a considerable capacity for heat storage. Turbulence is induced both in the passages leading to the cylinder and in the one connecting the two chambers. Energetic mixture formation is ascribed to this feature and to the storage effect of the linings. It is claimed that a reduction in ignition lag is thereby produced. A valve controlled by a handwheel can be secured in to close off the passage between the two chambers, and in this position the maximum compression pressure of approximately 600 lb. per sq in. is attained. This is claimed to make cold starting possible. (*Diesel Power*, vol. 9, no. 4, April, 1931, pp. 188–189, 2 figs., *d*)

Investigation of the Discharge Rate of a Fuel-Injection System

THE interpretation of indicator cards taken from compression-ignition engines is difficult because of the variation in the weight and heat contents of the mixture during the engine cycle due to the injection of the fuel. The interpretation requires, among other things, a knowledge not only of the time of start and cut-off of the fuel spray, but also of the rate of fuel injection.

DeJuhasz developed an apparatus for determining the rate of fuel discharge, using a constant-pressure injection system. He utilized a stationary receiver located opposite a cam-actuated injection valve. Between the receiver and the valve was a rotating disk with a slot. By means of this apparatus DeJuhasz obtained some valuable results on the angular rate of fuel discharge. He found that by increasing the oil pressure the period of injection was increased and that the maximum rate occurs earlier in the period; and that the rate of discharge was more uniform at higher camshaft speeds and with smaller orifices.

The purpose of this investigation was to determine the rate of fuel discharge from a cam-operated pump and automatic injection valve for a constant setting of the fuel-pump controls and a speed of 750 r.p.m. The investigation was conducted at the Langley Memorial Aeronautical Laboratory of the National Advisory Committee for Aeronautics, at Langley Field, Va.

In connection with the development of a method for analyzing indicator cards taken from high-speed compression-ignition engines, this investigation was undertaken to determine the average quantity of fuel discharged during each crank degree of the injection period. The fuel discharged by a cam-operated pump and automatic injection valve was collected in a rotating receiver. The weight of fuel discharged per unit time was determined for various crank-angle positions over the entire injection period.

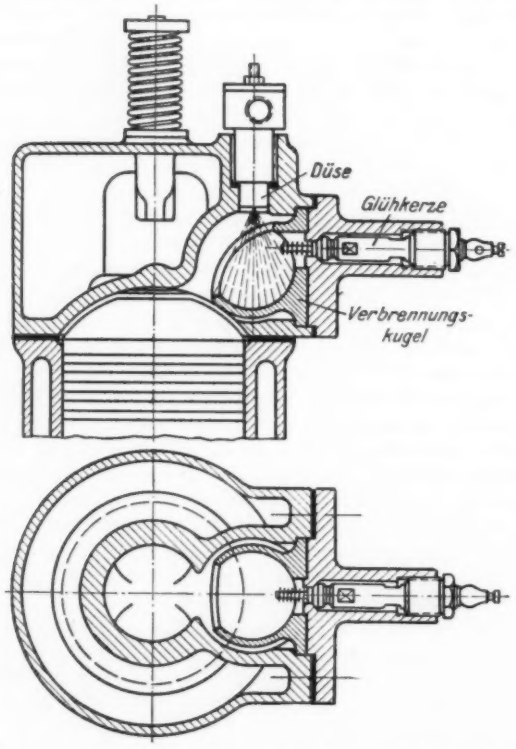
The results show that 98 per cent of the fuel was discharged during an interval of 25 deg., whereas the duration of the period from the start to the stop of the fuel spray was 68 deg. The duration of the period as obtained in these tests checks with the results obtained with the oscilloscope. During the 29 crank degrees after the start of injection and the 14 deg. before the stop of injection, only 2 per cent of the total weight of fuel is discharged.

The rate of fuel injection continued to increase for 7 deg. after the pump bypass valve opened. Calculations show that this interval is required for the pressure wave in the fuel to travel by the bypass valve to the injection nozzle. (Harold C. Gerrish and Fred Voss in *National Advisory Committee for Aeronautics, Technical Notes*, no. 373, April, 1931, 11 pp. of text and 5 pp. of illustrations, *e*)

Oberhaensli 4-Cylinder Automotive-Type Diesel Engine

THIS is a single-acting four-stroke-cycle engine using a Bosch injection valve for fuel injection with a Bosch or Ref pump. In starting, a Bosch glow plug is used which is heated by current from a storage battery. When the engine gets going the current is cut off from these glow plugs. The particular feature which characterizes this engine is the construction of its combustion chamber. This latter is separated from the cylinder by a throat and has inside it a spherical bowl with an interspace so arranged that the air in the process of compression coming from the cylinder is divided into two streams, both char-

acterized by a high degree of turbulence. One portion of the air comes in contact with the jet of fuel inside the combustion sphere while the other portion envelops the dish, which latter is quite hot, and is heated by this contact. The second portion of the air aids the combustion initiated by the first portion. The fuel is injected into the bowl toward the end of the compression stroke. The purpose of this arrangement is to permit the engine to ignite the fuel in a reliable manner even at comparatively low pressures and low r.p.m., and is said to provide excellent combustion under widely varying conditions of operation. In accordance with the demand on the engine the pump regulates the admission of the fuel. The initial point of the fuel delivery remains constant, but the end point varies in accordance with the



FIGS. 2 AND 3 VERTICAL (*above*) AND HORIZONTAL (*below*) SECTIONS THROUGH THE COMBUSTION CHAMBER OF ONE CYLINDER OF THE OBERHAENSLI DIESEL ENGINE

(*Düse*, nozzle; *glühkerz* = glow plug; *verbrennungs-kugel*, combustion sphere.)

time at which the compression space is placed in communication with the suction space. The amount of fuel injected is, of course, varied by the same arrangement.

The original article quotes two series of tests made to determine the performance of the engine. The first series show the engine performance at a constant speed of rotation. In the second series the engine carried a load at a given speed as long as the combustion remained perfect. The engines thus far built have a nominal output of 80 hp. at 1350 r.p.m., a bore of 130 mm. (5.1 in.) and a stroke of 180 mm. (7.1 in.). The piston velocity is 8.1 m. (26.57 ft.) per sec. It is claimed that the tests have shown that the specific fuel consumption remains particularly constant over a considerable range of load, and that when the output of the dynamo and fan are subtracted, the consumption is about 200 gr. per hp-hr. (0.44 lb. per hp-hr.) At its maximum output the engine delivered 102.8 hp. with a mean piston pressure of 7.02 atmos.

It is claimed that the torque increases with a decrease in the speed of rotation up to about 1130 r.p.m. The comparatively low maximum pressures prevailing in the cylinder are due to the extension of combustion over a considerable period of time. The initial combustion obviously takes place in the combustion sphere, but the second and concluding combustion takes place in the cylinder. Because of the subdivision of the stream of compressed air into two streams of great turbulence and their cooperation with the combustion sphere, which latter further heats the second stream of air and thereby helps to burn rapidly and completely the residue of fuel in the cylinder, it is found that even at high revolutions, in which the time available for combustion is comparatively short, the conversion of the chemical energy of the fuel into heat takes place rapidly and without material loss.

It is claimed that when the glow plugs were heated the engine started from cold easily and without smoking.

A table in the original article gives comparative data for the present motor and three others, namely, the six-cylinder Daimler-Benz, the six-cylinder M.A.N., and the four-cylinder spark-ignited Hesselman. (Kurt Neumann, Hanover, in *Zeitschrift des Vereines deutscher Ingenieure*, vol. 75, no. 15, Apr. 11, 1931, pp. 453–455, 6 figs., *d*)

Development of an Impinging-Jet Fuel-Injection Valve

PRELIMINARY tests showed that two smooth jets impinging upon each other at an angle of 74 deg. gave a spray with the desired characteristics. Nozzles were built on this basis and, when used in fuel-injection valves, produced a spray that fulfilled the original requirements. The spray is so well dispersed that it can be carried along with an air stream of comparatively low velocity or entrained with the fuel jet from a round-hole orifice. This characteristic of the spray upon an impinging-jet nozzle limits its application to situations where wide dispersion is required by the conditions in the engine cylinder and the combustion chamber.

The staff of the National Advisory Committee for Aeronautics at the Langley Memorial Aeronautical Laboratory has undertaken the investigation of the possibilities and limitations of the two-stroke-cycle high-speed fuel-injection engine as a means for increasing the power per unit of displacement obtainable from an engine suited to aircraft use. For this investigation it was desirable to have an engine capable of covering a wide range of experimental conditions. This requirement made the design of the fuel-injection valve and nozzle, as well as other accessory parts for this engine, a rather difficult problem.

The cylinder for this engine had been decided upon before the design of the fuel-injection valve was started, and had four holes that could be used for the fuel-injection valve or valves. These holes were in pairs diametrically opposed: one hole of the first pair in either side of the combustion chamber and the other pair similarly arranged in the cylinder wall just above the air-admission ports so that the fuel could be injected into the air stream as it entered the cylinder. As this air flow could be controlled to be either radial or tangential to the cylinder, the spray had to be nearly circular in shape, perpendicular to the axis of the cylinder, and, at the same time, well dispersed. For the radial flow with injection into the combustion chamber, the residual-air flow is negligible and the movement of the oil must be depended upon for proper distribution. For tangential flow the residual velocity in the combustion chamber is low and therefore the spray must be well d spersed to obtain proper distribution. For either type of air flow, with injection through the lower cylinder-wall holes the spray must be well dispersed to follow this air flow and produce a proper mixture of fuel and air (internal carburetion).

The dispersion requirement seemed most important, and impinging jets offered the simplest means of obtaining this disper-

sion. A preliminary test apparatus was assembled to determine the requirements of a fuel-injection valve nozzle built on the impinging-jet principle.

Although only a few of these nozzles have been built, there has been no difficulty in making them within the necessary tolerance to insure proper impingement. The formation of the liquid disk at the proper angle under low pressures is a sufficient indication that the operation of a nozzle of this type will be satisfactory. The impinging-jet nozzle is simpler to construct and has a higher coefficient of discharge than any other means used at this laboratory for obtaining comparable dispersion.

The impinging-jet nozzle gives an apparently well-atomized spray with good dispersion over the entire spray pattern. This spray has a low velocity, and therefore a small total penetration, but its wide dispersion allows it to be carried along with air flowing at comparatively low velocities. This spray should not be used unless other conditions in the cylinder and combustion chamber are conducive to its proper utilization. (J. A. Spanogle and G. T. Hemmeter, Langley Memorial Aeronautical Laboratory, in *National Advisory Comm. for Aeronautics, Technical Note No. 372*, April, 1931, 9 pp. of text and 7 pp. of illustrations, *c*)

ture range over which such an oil will prove serviceable. Copies of this chart may be secured by communicating with the Sinclair Refining Co., 45 Nassau St., New York City, attention of C. M. Larson (Mem. A.S.M.E.), Supervising Engineer. The price per 100 sheets is $4, which should be remitted with orders. (*S.A.E. Journal*, vol. 28, no. 4, April, 1931, text p. 496 and chart p. 497, *p*)

MARINE ENGINEERING

The Pacific Liner "Empress of Britain"

THE hull of this liner is of the cruiser type and is fitted with a type of boiler invented by John Johnson, superintendent engineer of the Canadian Pacific.

The Johnson boiler consists of two large-diameter drums, placed vertically one above the other and connected to each other by curved tubes which are arranged longitudinally and across the ends in such a manner that the combustion space is almost entirely enclosed by water tubes. In addition, there is a wall of water tubes along the center of the boiler which divides the combustion space into two separate compartments. With this

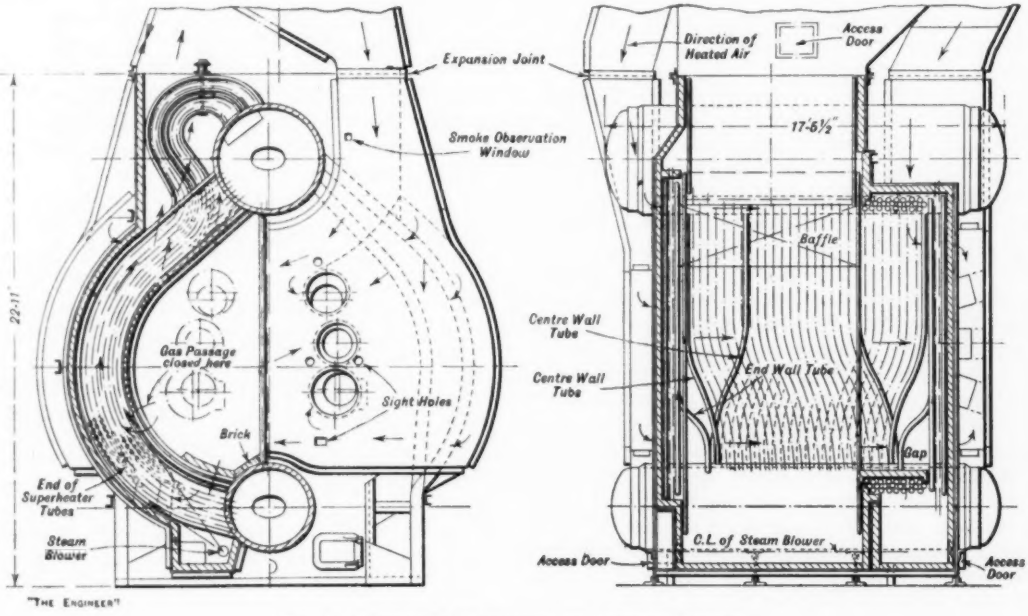


FIG. 4 SECTIONAL ELEVATION OF JOHNSON BOILER

LUBRICATION

Viscosity-Temperature Chart for Lubricating Oils

THIS is a simplified chart for plotting viscosity-temperature curves and permits straight-line plotting of viscosities of from 200,000,000 Saybolt universal sec. at 25 deg. fahr. below zero to 36 sec. viscosity at 450 deg. fahr. The chart has been checked to 50,000,000 sec. viscosity, and it is possible to carry curves on the heavier viscosity lubricants used for rear axles and transmissions, as well as for extremely low and high-temperature information that is not available on other charts. In addition, plotting the straight-line viscosity curve of the engine oil by first fixing the viscosity determinations at 100 deg. and 210 deg. fahr., enables one to ascertain the correct viscosity readings at any desired temperature. By fixing the 50,000-sec. viscosity mark as the maximum for easy starting at low temperatures and the 60-sec. viscosity mark as the minimum for warm-weather or high-speed safe performance, it is possible to determine the temperature

arrangement of tubes a considerably larger amount of the tube surface is exposed to radiant heat than in other types of marine water-tube boilers. (Fig. 4.)

The engines drive four screws, each impelled by an independent set of single-reduction geared turbines of the Parsons type. The *Empress of Britain* will run under two conditions, direct voyages between Canada and Great Britain during the summer, and world cruises in the winter. To suit these conditions the engines driving the two inboard screws are designed to develop two-thirds of the total power, while the engines driving the two outboard screws develop the remaining one-third. In other words, the power of the outboard engines is only half that of the inboard engines. Under cruising conditions, if full power is not required, only the inboard engines will be used, and the vessel will then be virtually a twin-screw ship. The machinery has been designed to develop normally a total output of 60,000 s.hp. continuously at sea, in order to maintain a normal speed of 24 knots. If an increase of speed is necessary at any time, however,

an overload power of 64,000 s.hp. can be maintained for long periods.

The main-turbine sets each comprise one high-pressure, one intermediate-pressure, and one low-pressure turbine working in series. The maximum working pressure for the high-pressure turbines is 425 lb. per sq. in., with an initial steam temperature of 725 deg. fahr. The turbines have been designed to develop the service and overload powers when employing steam between the limits of 375 lb. per sq. in. gage and 0.50 lb. per sq. in. abs. with an initial steam temperature of 700 deg. fahr.

Only one of the boilers is of the Johnson type, while eight are oil-fired water-tube boilers, of the double-flow, side-fired Yarrow type, having one steam drum, three water drums, and one superheater drum. In addition there are two cylindrical boilers of the return-tube type for auxiliary purposes.

Resulting from Mr. Johnson's new conceptions of high-pressure steam practice have been notable economies. The "Duchess" type of passenger steamships attained a fuel economy of 0.625 lb. of oil per shaft hp. per hr. for all purposes, and still more recently the *Empress of Japan*, also of the Canadian Pacific, set up a world record of 0.603 lb. Both of these records, notable as they were, were shattered by the *Empress of Britain* when during seven days of exhaustive trials the new 758-ft. liner set up a new record of 0.57 lb. per s.hp. per hr. for all purposes.

The ventilation engineers and equipment manufacturers had to solve some special problems, because the *Empress of Britain* is to travel between Southampton and Quebec between April and December, and cruise around the world between December and April. Thermo-tank machinery of a special type had to be devised to meet the problem, which involves a complete change of air every 7½ min., and the supplying of 30,000,000 cu. ft. of fresh air every change. This incidentally works out at the interesting figures of 400,000 cu. ft. of air per capita for the 1153-passenger list (there are 680 officers and crew), suggesting that there is unusual roominess below decks. Some 130 thermo-unit tanks, connected with each other and the ball-louvre ventilation outlets and exhaust air fans by 10 miles of piping, handle the problem of maintaining a 250-deg. temperature in the Turkish baths and 18 deg. above zero in the frosted rooms of the food-supply department. This special ventilating system has been extended to the engine rooms so that engineers and oilers will have to accustom themselves to new low temperatures as compared with the older, intense heat of the hold. (*Canadian Pacific Railway News*, mimeographed publication, *d*, and Part III of a serial article in *The Engineer*, vol. 151, no. 3932, May 22, 1931, pp. 567–569, illustrated)

MECHANICS

Strength and Durability of Spur-Gear Teeth

THE maximum dynamic load on gear teeth is the sum of the applied load and an additional or increment load resulting from the inertia of the masses and the variations in velocity set up by the action of the effective errors in the gear teeth. This maximum load is but momentary, yet the teeth must be strong enough to carry it. The following equations apply to metal spur gears. Let:

W = total tooth load transmitted, lb.
T = width of gear face, in.
f = applied load in lb. per in. of face
V = pitch-line velocity in ft. per min.
I = increment load in lb. per in. of face
f_2 = load in lb. per in. of face required to deform teeth the amount of the effective error
C = tabulated value representing load required to deform tooth of given material and form a given amount
W_d = total maximum dynamic tooth load, lb.

Then:

$$f_2 = f + C \quad [1]$$

$$f = \frac{W}{T} \quad [2]$$

$$I = \frac{0.05\,Vf_2}{0.05\,V + \sqrt{f_2}} \quad [3]$$

$$W_d = T(f + I) \quad [4]$$

The value of C will vary in direct proportion to the extent of the error.

A table in the original article gives the values of C for several groups of materials, while another table gives the values of I as calculated by Equation [3] for pitch-line velocities up to 5000 ft. per min., corresponding to values of f_2 up to 6000 lb. The author gives next an expression to measure the beam strength of the gear teeth to insure that they will be strong enough to withstand this dynamic load without breaking. This is done by means of the Lewis formula, and to simplify the use of this material, tables have been prepared which give the static beam strength of 1-D.P. gears of 1-in. face for the three most commonly used gear-tooth systems. Next comes an expression to measure the durability of the surfaces of the gear teeth so as to avoid excessive wear. Letting

W_w = limiting static tooth load for wear, lb.
D = pitch diameter of pinion, in.
T = width of face, in.
Q = ratio factor
K = load-stress factor
n = number of teeth in pinion
N = number of teeth in gear
E and E_2 = moduli of elasticity of material
S_f = compressive-fatigue limit stress for material, lb. per sq. in.
A = pressure angle of tooth form,

Then

$$Q = \frac{2N}{n + N} \quad [6]$$

$$K = \frac{S_f{}^2 \sin A}{1.400}\left(\frac{1}{E_1} + \frac{1}{E_2}\right) \quad [7]$$

$$W_w = DTKW \quad [8]$$

A table in the original article gives values for K corresponding to the probable fatigue limit stress for the materials. For the sake of simplicity a pressure angle of 14½ deg. has been employed in computing these tabulated values. The author gives an example showing the application of his formula. (Earle Buckingham, Asst. Prof., Mass. Inst. of Technology, and Chairman A.S.M.E. Special Research Comm. on the Strength of Gears, in a paper before the 15th Annual Meeting of the American Gear Manufacturers Association; abstracted through *The Iron Age*, vol. 127, no. 22, May 28, 1931, pp. 1742–1745, *tA*)

MOTOR-CAR ENGINEERING (See Internal-Combustion Engineering: Oberhaensli 4-Cylinder Automotive-Type Diesel Engine)

POWER-PLANT ENGINEERING

Steam Turbines

THE N.E.L.A. report here abstracted presents in detail the 1929 operating records of 276 turbines of 20,000 kw. and larger capacity as compared with 207 in the year 1928, and 191 in the year 1925. The average capacity of units installed increased from 42,050 kw. in 1928 to 65,430 kw. in 1929, or 56 per cent. The capacity of turbines with one year of service as reported for the year 1929 totals 1,474,500 kw. for 26 units; similar data for the year 1928 showed a capacity of 970,200 kw. for 21 units. A review of the average annual operating factors seems to indicate that the total installed capacity for the year 1929 is much in excess of the load requirements. The 1929 record shows a slight increase in the percentage of total time the units were available for service, with a slight increase over the year 1928 in percentage of total time the units were unavailable for service.

Outside annual inspection and adjustment, troubles incident to turbine blading still constitute the great single cause of turbine outage. However, the total outage per unit affected due to this cause dropped from 440 hr. in 1928 to 294 hr. in 1929.

An investigation of the average time required for annual inspection and adjustment of machines disclosed this to be approximately the same for machines of all capacities. Of a total of 276 turbines analyzed for 1929, 100 did not report any outage for annual inspection and adjustment.

Tests on turbo-generator units ranging in capacity from 3500 to 94,000 kw. are included. Many of these reported were made of units operating on the regenerative cycle, and test data are presented on the performance of extraction heaters and generator air coolers as well as on the turbine and generator.

The report contains statements by operating companies on newly installed large-capacity units and unusual operating conditions. Manufacturers' statements on large steam turbines and on the recent trend to vertical compound turbines and turbines used for auxiliary drive are included.

The work of the committee has been confined to compiling turbine operating data for the year 1929 and the presentation of such turbine test data as were available.

No outstanding turbine troubles which seemed to require special investigation were reported.

As noted, brief operating statements were obtained concerning some of the large units referred to in previous reports which went into service during 1929.

Fig. 1 in the original report shows the 1929 operating record for each unit reported with its service-hour factor plotted against its total outage factor in per cent of its total period hours.

It is interesting to note that 101 units of a total of 292 reported had a service-hour factor of 80 per cent or greater, with an average unit outage factor of 7.2 per cent. For the same service-factor range for 1928 with 62 units considered, the average unit outage factor was 6.6 per cent, showing a slight increase in outage for the year 1929. In 1929, 237 of the 292 units reported had a service-hour factor greater than 50 per cent with an average unit outage factor of 8.9 per cent. For the same service factor range in 1928 with 163 units considered, the average total outage factor was 9.9 per cent, showing a decrease of 1 per cent for 1929.

As was the case in 1928, the 40 to 50 per cent service-factor group shows the highest average unit outage factor. In 1928 it was 15 per cent for 24 units considered, while in 1929 it was 16 per cent for 22 units considered. A table given shows that the average total outage factor for all machines reported is 9.82 per cent, which indicates that the higher-service-factor-class machines are well under the average total outage factor for 1929.

It is apparent that the units with 80 to 100 per cent service factors are of the base-load type, since in most cases they show very little reserve time, the total time being divided between operating and outage. The fact that the highest total outage lies in the 40 to 50 per cent service-factor group would seem to indicate that the continuous starting and stopping of units influences the availability of machines.

Several statements from operating companies are reproduced. The United Electric Light and Power Company states in reference to their two 160,000-kw. units at Hell Gate Station that the low-pressure end of the American Brown-Boveri unit began to vibrate on January 30, 1929. It was found that several of the lashing wires in the last two wheels were broken; there were also indicated eight breaks in wires of the sixth and eighth wheels. Since the calculations indicated that vibrations of a nature to cause these troubles were not to be expected, it was assumed that stresses due to soldering were the cause of the fractures. The lashing wires were removed and the turbine returned to service for trial operation pending further investigation. Operation under this condition, however, was not successful, the strains causing fractures of the shroud band and of one blade. As service from this unit was important it was returned to service without the last wheel on each end, and has been operating in this condition ever since.

The Westinghouse unit has been operating practically without interruption. The general practice has been to operate the two units as nearly continuously as load requirements will permit, but the operating procedure differs somewhat for each of these units. This procedure is stated in detail.

In the 110,000-kw. unit at the Hudson Ave. Station vibration developed shortly after the installation. It was found to be due to spindle warpage, and when this was eliminated, the vibration disappeared.

Steam-consumption performance tests are presented for twenty turbines ranging from 3500 to 94,000 kw. with steam conditions from 190 gage and 484 deg. fahr. total temperature up to 400 lb. gage and 725 deg. fahr. total temperature. One of the tests gives a complete analysis of the turbine, generator, and extractor-heater performance for a 94,000-kw. unit. (Report of the Prime Movers Committee, Engineering National Section, *National Electric Light Association Publication No. 078*, Aug., 1930, 78 pp., 100 pp., *eA*)

Relationship Between the Heat of Combustion, the Heating Value, and the Volatile Constituents of Bituminous Coal

THE purpose of the investigation dealt with in this article is primarily to facilitate controlling the purchase and use of bituminous coal. This calls for a simple, quick, and cheap method of determining the combustion value of a coal. The relationship between the heating value of a coal and its content of volatile constituents has already been extensively investigated. De Jonge found that the heat of combustion of the volatile constituents Q_v is a linear function of the content of volatile constituents in the sense that their heating value decreases with the increase in volatile constituents, while the heat of combustion of the fixed carbon Q_c is constant.

$$Q_c = A \quad [1]$$

$$Q_v = B - Cv \quad [2]$$

Since the heat of combustion of pure coal is

$$Q_r = Q_c c + Q_v v \quad [3]$$

and since further the content (c) of fixed carbon C_{fix} and of the fluid constituents v must be equal to 1,

$$c + v = 1 \quad \ldots\ldots [4]$$

one can write

$$Q_r = Q_c(1 - v) + Q_v v \quad \ldots\ldots [5]$$

or, finally, by introducing $B - A = D$,

$$Q_r = A + Dv - Cv^2 \quad \ldots\ldots [6]$$

Introducing the values of the constants found by de Jonge,

$$Q_r = 8150 + 6850v - 17{,}500v^2 \quad \ldots\ldots [7]$$

Similarly one may write for the heating value of pure coal the equation

$$H_r = A' + D'v - C'v^2 \quad \ldots\ldots [8]$$

It may be mentioned in this connection that by Q or heat of combustion, the author means the upper heating value of the fuel, and by H, the lower heating value.

The values of the constants here employed were fixed on the basis of 90 determinations of the heat of combustion carried out by the Thermochemical Institute of Dr. Aufhäuser at Hamburg and 100 determinations of the lower heating value of the same fuel carried out at the same place, together with ten determinations taken from the 25th edition (vol. 1, p. 872, of the German Engineering Handbook, "Hütte"). From these the following two approximate equations have been derived:

$$Q_r = 8150 + 6650v - 17{,}500v^2 \quad \ldots\ldots [9]$$

and

$$H_r = 8150 + 3833v - 11{,}806v^2 \quad \ldots\ldots [10]$$

The value of the constant A can be considered as sufficiently well known. Roth, for example, gives 8148 kg-cal. per kg. (14,666 B.t.u. per lb.) as the lowest value for the heat of combustion of amorphous carbon. While he found for sugar carbon a value of 8150 kg. cal. per kg. (14,670 B.t.u. per lb.). The two other constants D and C have been calculated by the method of least squares from Equations [9] and [10]. Both of them have been determined from some 90 to 100 equations established on the basis of extensive calculations.

$$Q_r = 8150 + 6543v - 17{,}308v^2 \quad \ldots\ldots [11]$$

$$H_r = 8150 + 4489v - 13{,}964v^2 \quad \ldots\ldots [12]$$

Equation [11] gives the heat of combustion, and Equation [12] the heat content.

These equations which give the heat of combustion and the heating value of pure coal as a function of their content of volatile constituents can be used for determining the heating value from data of abbreviated analyses.

The author refers in this connection to a Fig. 1, which, however, does not appear in the original article. He shows that a maximum value is obtained for a certain value of v and derives equations to cover the heat of combustion and lower heating value for the volatile constituents. The difference between the upper and lower heating values increases with the increase in content of volatile constituents, and then begins to fall off according to the relation

$$Q - H = 2054v - 3444v^2 \quad \ldots\ldots [13]$$

It should be borne in mind, however, that these values are for pure coal and consider therefore only the water of combustion. They are subject to certain further limitations. A curve in the original article shows that the above formulas apply only to the case of natural fuels and not to mixed fuels. (Wilhelm Gumz, Charlottenburg, in *Feuerungstechnik*, vol. 19, no. 1, Jan. 15, 1931, pp. 1–3, 2 figs., *g*)

A Study of Air Preheaters

THIS paper describes tests on models of air economizers and is preceded by a general discussion of the subject of tests on models. In the present instance water was used on the air side of the economizer, and, not being equally elastic, did not give a complete picture of the movement of air. However, the purpose of the test was to determine why in an economizer of a given design as illustrated in Fig. 6 there was a tendency for the moving fluid to form places of stagnation, leading in the actual economizer to an improper transfer of heat. The walls of the model were made of glass, and the flow of water could be observed by introducing drops of black dye at various spots. Fig. 6 shows the places where the dye was introduced and indicates diagrammatically its motion, while Fig. 7 shows part of the film for curve 3 in Fig. 5, i.e., the motion of the water in the model corresponding to the same Reynolds number, which holds good for the motion of the air in the economizer.

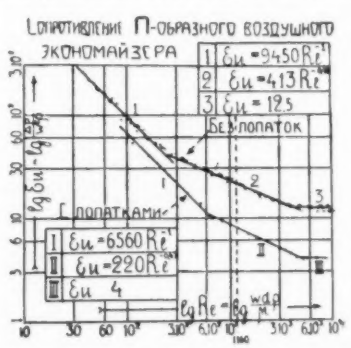


FIG. 5 CURVES OF OPERATION OF ECONOMIZER MODELS WITH AND WITHOUT PRANDTL DIVIDERS

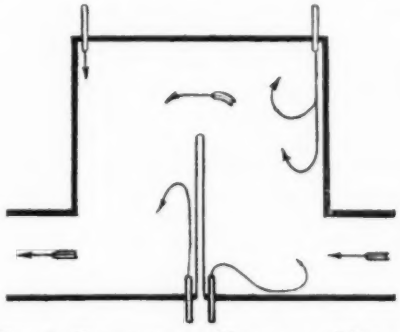


FIG. 6 DIAGRAMMATIC VIEW OF A MODEL OF ECONOMIZER WITHOUT DIVIDERS

FIG. 7 PHOTOGRAPH OF OPERATION OF THE ECONOMIZER MODEL SHOWN IN FIG. 6

The value of R_e for Fig. 7 is 10,000 and hence very much greater than at the critical velocity, which is 2200. In this region the forces of inertia are considerably greater than the viscosity, and therefore the change in the value of R_e does not affect materially the picture of the motion. In other words, the economizer works in the "automodel" region, which means that when the velocity of the air increases, the distribution of velocities in the various parts of the economizer is very little affected. This fact incidentally tended to prove that the motion of water in the model correctly represents the motion of the air in the economizer. The velocities at various points of the economizer as measured with the Prandtl tube were found to coincide with the distribution of velocities observed on the model.

The flow of water does not move through the entire section, and at the corners and turns practically stagnant places are

observed. These stagnant places are particularly prominent in the upper right-hand corner, where the entire mass of water slowly turns in clockwise direction. The motion of water along the wall takes place in the direction of return flow, and a dye injected in the corner slowly moves downward and is then washed away. The same situation was observed on the left side of the center wall. Here the dye rises, and when it reaches the top, is washed away by the stream. This irregular operation of the flow in the economizer must result in producing high hydraulic resistance in the economizer passages, and a great reduction in the surface actively engaged in heat exchange.

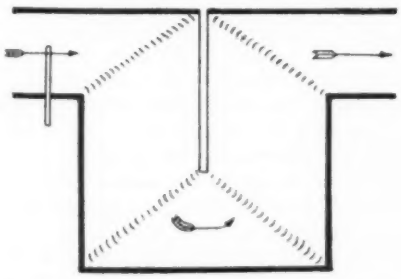


FIG. 8 DIAGRAMMATIC VIEW OF AN ECONOMIZER WITH PRANDTL DIVIDERS

As a result of these observations an attempt was made to find ways to eliminate the difficulties of economizer operation.

Recently Prandtl offered a very clever method of eliminating turbulent spots in the aerodynamic tunnel of the Göttingen Laboratory, namely, placing "dividers" in the bend of the bend of the tunnel in order to divide the entire stream into a series of small flows and to produce a turn in each little stream separately. In the present investigation Prandtl dividers were placed in the model and the flow of water shown in Figs. 8 and 9 was obtained. All the stagnant places disappeared, and the flow began to move through the entire section. Colored water introduced near the walls no longer shows stagnation in the corners, and the dye added to the main stream in its upper part shows that the entire mass of water moves in a solid stream.

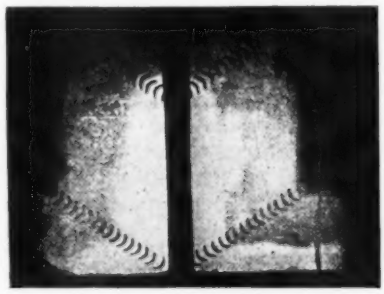


FIG. 9 PHOTOGRAPH OF OPERATION OF ECONOMIZER SHOWN IN FIG. 8

Investigation of the resistance of water in the model when equipped with the Prandtl dividers gave no less remarkable results. These are shown in Fig. 5 as curves I, II, and III. The resistance was particularly low in the region of turbulence III as compared with curve III before, namely, one-third of the original.

Fig. 5 has been obtained experimentally by two engineers of the Russian Physico-Technical Institute and shows a logarithmic anamorphosis of the curve E_u or the Euler number equal to $f(R_e)$, the latter being the Reynolds number.

The curve consists of three parts. The first (1) is inclined at 45 deg., which means that the coefficient of resistance is inversely proportional to the velocity of flow and the fall of pressure is directly proportional to the first power of the velocity. The motion of water is therefore here laminar.

Curve 2 shows that the resistance increases more rapidly. In other words, we are dealing here with the region of transition through the critical number as indicated by the vertical dotted line. Curve 3 is horizontal and represents the region of turbulent motion where the fall of pressure is proportional to the square of the velocity. At the right-hand corner of the drawing under curve 3, a point on the horizontal dotted line corresponds to $R_e = 10^1$ and gives the results of previous tests of the economizer.

Curves 1, 2, and 3 were obtained without, and curves I, II, III with, the Prandtl dividers. (M. B. in a paper before the 5th All-Union Thermotechnical Conference of the Leningrad Regional Energy Commission, Committee on Boiler Manufacture, reprinted from *Proceedings of the All-Union Thermotechnical Institute* (in Russian), Part I (61), 1931, pp. 52–55, 5 figs., *e*)

PUMPS

The DeLaval Clogless Pump

THIS is a centrifugal pump intended for handling liquids carrying solids which, if not properly provided for, tend to cause clogging. It is designed particularly for handling sewage, paper pulp, and similar liquids. The casing is split in the plane of the shaft, with a discharge connection in the lower half or casing proper. The casing cover can therefore be lifted off without disturbing the discharge-pipe connection, and after only partial unbolting of the suction-pipe connection.

The purpose of this is to make the inside of the pump easily accessible. The suction nozzle is designed for a large-size suction pipe, insuring low pipe velocities and low total suction head, which is conducive to smooth and efficient operation of the impeller.

The lower half, or pump casing proper, has cast integral with it a pedestal or supporting foot which is designed to be bolted

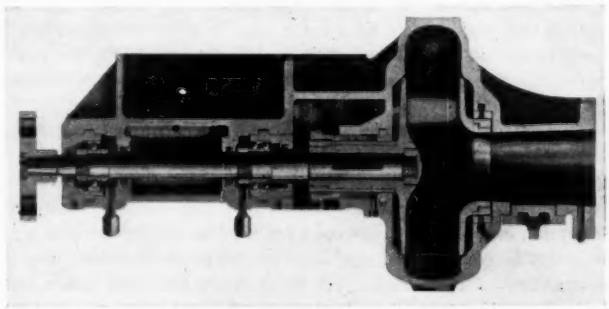


FIG. 10 DE LAVAL CLOGLESS PUMP

directly to the bedplate of a motor- or engine-driven unit. The pump volute or body is overhung, making the piping connections easily accessible. The seats for the bearings, the packing gland, and the sealing-ring recesses are all bored at one setting, insuring perfect alignment.

The passages through the impeller are extra wide, both between the side plates and between the vanes. Ordinarily only two vanes are used, proper guiding of the liquid without cavitation or shock being attained by suitable selection of the speed and of the impeller diameter. Many of the difficulties heretofore experienced with pumps handling viscous liquids or liquids carrying solids have been due to the use of too high speed; while slow-speed pumps for this service have generally been of cheap construction and have given very low efficiency. By suitably proportioning the impeller passages and volutes, the present pumps, which are operated at slow speed, have been made to compare favorably in efficiency with standard high-speed clear-water pumps. Where the pump capacity or the nature of the liquid permits, the number of impeller blades is increased to three or four, permitting higher speed.

At the joint between the impeller and casing the impeller is protected by a bronze ring threaded upon it, while the casing is protected by a stationary bronze ring seated in recesses formed in the casing and casing cover, and therefore removable when the

cover and rotor are lifted. A circumferential slot in the stationary ring communicates with a tapped opening through the casing cover to provide for sealing with clear water under a pressure slightly higher than that generated by the pump, in order to prevent liquid and abrasive matter handled by the pump from entering between the rings.

For some services an open impeller is used, with removable stationary side plates of special form held in recesses in the pump casing and cover to guide the liquid during its passage through the impeller. The knife-like edges of the impeller blades, running close to these side plates, cut or shear stringy material. The efficiencies obtained are very nearly equal to those of the enclosed impellers.

In order to avoid too great overhang of the shaft, the stuffing box is located over the impeller hub, which is protected by a renewable bronze sleeve. A tapped opening in the casing cover provides for the introduction of clear sealing water at a pressure slightly higher than that of the pump, thus preventing the entrance of solids to the soft packing and consequent cutting of the hub sleeve.

Ball bearings are used, the one next to the impeller being of the duplex type and arranged to take all unbalanced thrust, including the weight of the impeller and shaft when the pump is installed with the shaft vertical. The outer bearing is of the single-row type, and is intended to take radial forces only, the outer race being slidable, which prevents binding due to any inequality in expansion of shaft and pedestal. The bearings are spaced well apart. A flexible coupling which will not transmit end thrust and which allows for unavoidable misalignment is used to connect the pump shaft to the driving shaft, the pump half of the coupling being mounted upon a taper fit to permit easy removal.

For vertical-shaft operation this pump is constructed as for horizontal operation, the thrust bearing being heavy enough to take all additional load imposed by the weight of the rotor. The pedestal or foot of the pump can be bolted to I-beams or channels, involving no change whatever from the horizontal design, or a semicircular foot for supporting the pump on the floor can be cast as part of the casing. (H. L. Watson, DeLaval Steam Turbine Co., Trenton, N. J., in a description not previously published, *d*)

RAILROAD ENGINEERING

A High-Pressure Locomotive

THE author discusses the general question of efficiency of present-day locomotives and describes a number of high-pressure locomotives built in various countries, such as the Ljungström, Zoelly, Krupp, Maffei, and Henschel. He comes to the conclusion that under no conditions now existing is there any advantage in employing pressures in excess of 60 atmos., and that while the various attempts to use high pressures mentioned above have brought about certain encouraging results in the way of improving the thermal efficiency of the locomotive propelling plant, none of the designs hitherto constructed have shown sufficient indications of vitality to be able to affect the motive-power situation on the railroads generally. The improvement in thermal efficiency has been bought at a cost of more expensive and more complicated construction, resulting in increased maintenance costs. Moreover the new locomotives are less adapted to meet requirements of practical railroad experience. The author's general conclusion is that the reciprocating non-condensing engine has considerable advantages as compared with condensing-turbine locomotives, which latter are as yet in an experimental stage. Among the locomotives described in the original article, particular attention may be called to the Maffei, as it is equipped with a Benson boiler. The author points out, however, that the use of impure water and sudden changes of load not accompanied by correspondingly rapid change of heating may seriously affect the operation of the Benson boiler. The claim is made for this locomotive that its coal consumption is 0.60 kg. (1.32 lb.) per i.hp-hr. (P. Magnee, Divisional Inspector of the Northern Belgian Railroads, in *Revue Universelle des Mines de la Métallurgie et des Travaux Publics*, Series 8, vol. 5, no. 5, Mar. 1, 1931, pp. 139–148, 13 figs., *dg*)

RESEARCH

Cooperative Research in the Iron and Steel Industry

THE term "industrial research" is now being used to include all kinds of investigations that in any way benefit producing organizations and the consumers of their products. It includes investigations of marketing conditions, distribution, new sales fields, welfare of employees, and consumers' problems, as well as the study of fundamental scientific and engineering problems on which the industry is founded.

Technical problems of an industry like iron and steel may be divided into those that are competitive, such as developing of special improvements in processes and products—for instance, new rust-resisting steels—and those which are not competitive, which includes investigations of the principles of the processes employed—for instance, the study of the chemistry of steel making.

Investigating work of all kinds has increased to such an extent in recent years that it becomes a matter of considerable importance to study the economics of operation. Moreover experienced research men are none too plentiful. From this the author proceeds to a description of the organization of cooperative research in Germany, Great Britain, and America, dealing in the latter case specifically with the study of the physical chemistry of steel making, including in particular the study of non-metallic inclusions. This research led to the adoption for certain purposes of a silico-manganese alloy for purifying steel.

It is suggested that cooperative work in the steel industry be centered in a research board under the auspices of the Association of Iron and Steel Manufacturers, including advisory members representing cooperating interests. A brief list of literary references is given. (F. N. Speller, Director of Department of Metallurgy and Research, National Tube Company, Pittsburgh, Pa. Paper read before the *American Iron and Steel Institute*, May 22, 1931, preprint, 23 pp., *g*)

SPECIAL PROCESSES

Sizing and Sinking in Seamless Tube Manufacture

IN THE first part of this article the author describes the Mannesmann-Stiefel methods of making seamless tubing, and also the double piercing process developed in 1924 by the National Tube Company. From the piercing mill the hollow billet goes to the so-called plug mill, where it is elongated to the desired length, the wall thickness being decreased and the approximate outside diameter produced.

As the product leaves this mill it is not especially smooth of finish nor true as to diameter, but the wall thickness is definitely determined. It then passes to the reeler, which is somewhat similar to the piercing mill, performing an oblique rolling operation, and which, by means of another mandrel and the rolls, burnishes or gives a finish to both the outside and inside of the tube. The rolls used in this operation are flat instead of barreled as in the piercing mill. The tube is now slightly over the diameter desired, and it passes to a sizing mill with a single groove, or to a sinking mill (with several grooves) where it is brought to size.

Sizing may be by two methods: (*a*) rolling between one or more pairs of rolls to obtain the roundness and diameter desired, and (*b*) by the operation known as "sinking," wherein the tube is passed through successive pairs of rolls of diminishing groove diameters in order to produce a tube of a diameter smaller than it is practical to roll. For example, a 3-in. tube can be reduced to 2 in. or to $1^1/_2$ in. outside diameter by sinking; sizing is accomplished in this operation also. It has usually been found necessary in using this type of mill after the reeling operation to interpose a reheating furnace to bring the material back to a temperature (usually above the critical point) at which it will be plastic enough to flow readily.

The sizing mill, as distinguished from the sinking mill, is merely a single-groove two-high mill of such dimensions as to give the exact size desired, allowing of course for the contraction of the tube when cooling.

The sinking mill may consist of a continuous mill with as many as sixteen or more two-high rolls with diminishing groove diameters, the pass lines of which are in a straight line but whose axes are set at an angle of 90 deg. with one another. These rolls, of course, revolve at different speeds to match the elongation taking place in the tube as the diameter decreases. This speed allowance is such as to overcome, in most cases, any thickening of the wall due to decreasing the diameter of the tube.

A tube which has gone through the operations heretofore described and after delivery to the hot saw and cooling table is given the finishing operations and shipped, is known as a "hot-finished" tube.

Tubes which have gone through the preceding operations and after delivery to the cooling table are sent to the draw benches for cold drawing, form a class of product known as "cold-drawn tubes." (G. P. McNiff, Asst. Vice-President, National Tube Co., in a paper before the Western Metal Congress; abstracted through *Metal Progress*, May, 1931, pp. 39–45, illustrated, *d*)

TESTING AND MEASUREMENTS (See Power-Plant Engineering: A Study of Air Preheaters)

THERMODYNAMICS

An Equation for Heat Transfer in Fluids Flowing in Pipes

IN THIS article the author states that in a previous investigation he showed that the theoretical equation established by L. Prandtl (*Physikalische Zeitschrift*, 1910, p. 1072) for the transfer of heat gives results in closest agreement with experimentally obtained results for water when (1) the coefficients for the liquid varying with the temperature are substituted for the average values of the laminar boundary limit, and (2) when it is assumed that the following ratio holds good, namely,

$$\frac{\text{Velocity at Boundary of Laminar Layer}}{\text{Average Velocity of Flow of Fluid}} = 0.35$$

In order to facilitate the application of the Prandtl equation the author plotted the coefficients of heat transfer for water in the form of a set of curves (*Zeitschrift des Vereines deutscher Ingenieure*, vol. 75, 1931, p. 42, section 6). Elsewhere (in *Schweizerische Bauzeitung*, vol. 96, 1930, p. 325) he showed that the same equation gives values agreeing with those obtained experimentally for the case of highly heated air, which would seem to indicate that the applicability of the equation within a wide range is established. Even if individual measurements sometimes indicate deviations of theory from experimental results, this is due probably less to the lack of precision of the theory than to the great difficulty of obtaining flawless temperature measurements, and to the fact that the theory presupposes steady flow.

Quite recently A. Eagle and R. H. Ferguson (*Engineering* vol. 130, 1930, p. 692, and Proceedings of the Institution of Mechanical Engineers, London, 1930, pp. 985–1074), have made careful measurements on the heat transfer from water flowing through pipes. In Fig. 11 the author compares data for a pipe 16.56 mm. (0.652 in.) in diameter with values obtained from the theoretical equation. He also plots two boundary curves between which all the experimental values should lie. The lower

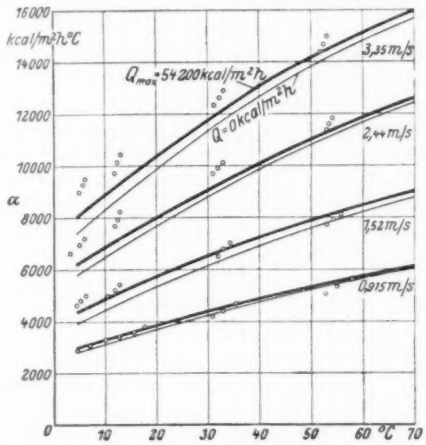


FIG. 11 COMPARISON OF RESULTS OBTAINED EXPERIMENTALLY BY EAGLE AND FERGUSON WITH THOSE DERIVED FROM PRANDTL'S THEORETICAL EQUATION

curve is plotted for an equal temperature of wall and water, in which case, of course, no heat will be transferred ($Q = 0$), and the upper curve for the maximum heat value which can be transferred experimentally (Q_{max} = 20,000 B.t.u. per sq. ft. per hr. = 54,200 kg-cal. per sq. meter per hr.), under which conditions the temperature difference between the wall and the liquid is a maximum. The agreement between theory and experiment is practically complete up to water velocities of 1.5 meters (4.92 ft.) per sec. At greater velocities deviations begin to appear and reach 3 per cent at 3.35 m. (11 ft.) per sec. and 54 deg. cent. (129.2 deg. fahr.) and become even larger at 4.5 deg cent. (40.1 deg. fahr.). The deviations of about 3 per cent may be traced to the fact that at the high velocity of 3.35 m. per sec. the steady flow presupposed by the theory no longer exists. The experiments carried out by L. Schiller on the loss of pressure in pipe lines have also shown that in order to obtain the steady flow very large admission passages (up to 200 diameters in length) are needed, and the length of the passages required for this purpose increases with the increase of the Reynolds number. Shorter admission passages (say, up to 44 diameters in length) have the effect of increasing by many per cent the pressure loss and hence the heat transfer.

The large deviations for theory at 4 deg. cent. (3.92 deg. fahr.) at which the viscosity of the water is three times as great as at 54 deg. cent. (129.2 deg. fahr.), direct attention to the question as to whether at very high velocities of flow or at high viscosities of the liquid, the mixing of the water when measurements of average temperatures are made, is so complete that it is really the average temperature that is being measured. Even an error as 0.1 deg. cent. (in view of the small difference of temperature between the pipe wall and water) would be sufficient to explain the difference between theory and experiment. For the purpose of transfer of experimental data to other conditions, the theoretical equation is considered by the author to be just as reliable as the empirical formula derived by Eagle and Ferguson from their tests. (Ten Bosch in *Zeitschrift des Vereines deutscher Ingenieure*, vol. 75, no. 15, Apr. 11, 1931, p. 468, 1 fig., *t*)

Instruments and Apparatus

Preliminary Draft of Part 2—Pressure Measurement: Chapter 2, Static and Total Pressure, Static Holes and Tubes, Impact Tubes; and Chapter 3, Pipes for Pressure Measurement

The Main Committee on Power Test Codes takes pleasure in presenting to the members of the Society for criticism and comment Part 2—Pressure Measurement: Chapter 2, on Static and Total Pressure, Static Holes and Tubes, and Impact Tubes; and Chapter 3, on Pipes for Pressure Measurement. The Individual Committee which has developed this draft consists of Messrs. C. F. Hirshfeld, Chairman, W. A. Carter, Secretary, C. M. Allen, E. G. Bailey, L. J. Briggs, C. R. Cary, J. D. Davis, R. E. Dillon, F. M. Farmer, J. B. Grumbein, W. H. Kenerson, E. S. Lee, E. L. Lindseth, O. Monnett, S. A. Moss, R. J. S. Pigott, E. B. Ricketts, and W. A. Sloan.

The "Instruments and Apparatus" Section will consist of twenty-one parts dealing with the following subjects: (1) General Considerations,[1] (2) Pressure Measurement (6 chapters),[2] (3) Temperature Measurement (9 chapters),[3] (4) Head Measurement, (5) Measurement of Quantity of Material, (6) Electrical Measurements, (7) Mechanical Power, (8) Measurement of Indicated Horsepower, (9) Heat of Combustion, (10) Flue-Gas Analysis, (11) Determination of Quality of Steam,[4] (12) Time Measurements, (13) Speed Measurements,[5] (14) Mechanical Measurements, (15) Surface Area, (16) Density Determinations,[6] (17) Determination of Viscosity of Liquids,[7] (18) Humidity, (19) Concentration of Dilute Solutions, (20) Smoke-Density Determinations, and (21) Leakage Measurements (2 chapters).[8]

Complete copies of the draft, which is published here in abstract, may be obtained from the Society's headquarters. The Individual Committee, the Main Committee, and the Society will welcome suggestions for corrections or additions to this draft from those who are especially interested in this subject. These comments should be addressed to the Chairman of the Committee, in care of The American Society of Mechanical Engineers, 29 West 39th Street, New York, N. Y.

Chapter 2—Static and Total Pressure, Static Holes and Tubes, Impact Tubes

CONTENTS

	Paragraph
Pressure Definitions	1
Pressure Correction by Bernoulli's Theorem	14
Static Holes	20
Static Tubes	32
Impact Tubes	38

PRESSURE DEFINITIONS

1 *Static Pressure* is the force per unit area exerted on a wall by adjacent fluid (liquid or gas) which is at rest or which is flowing with disturbance along the conduit wall. It is measured by use of a *Static Hole* in the wall, drilled perpendicularly to the surface adjacent to the fluid, as discussed in Pars. 20 to 31. *Static Pressure*, or merely *Pressure*, as it is often called, must be distinguished from *Total Pressure* and *Velocity Pressure*, discussed in Pars. 7 to 11 and 38.

2 *Pressure* as used herein is usually measured in pounds per square inch, denoted by p. Pressure in pounds per square foot, $144p$, is the value which usually occurs directly in equations of the foot-pound-second system. Pressures concerned with flow of fluid are often given in terms of "head," which is the height of a column of fluid in feet, at whose base exists the pressure p. If ρ is the density of the fluid (lb. per cu. ft.) and h is the head (ft.),

$$144 = h\rho$$

Owing to the common use of water U-tubes or mercury U-tubes, pressure measurements are often given as readings of these instruments, in inches of Mercury Column or inches of Water Column. However, in the case of Mercury Columns the reading is always to be corrected to the standard temperature of 32 deg. fahr. See Chapter 6, Pars. 5 to 18. Pressures are also occasionally given in atmospheres, on the basis that the Standard Atmosphere is 760 mm. of mercury, or 29.921 in. of mercury, which is 14.696 lb. per sq. in. Conversion factors for the various pressure units, allowances for water over mercury, etc. are given in Chapter 6, Table 7.

3 Pressure is measured by means of one of the *Pressure Measuring Instruments* described in Chapters 4 and 5, which is connected to the pressure hole by means of a Pipe for Pressure Measurement (described in Chapter 3).

4 *Accuracy of pressure measurements* must be attended to with proper discretion. There are three usual cases, as follows:

(*a*) Accurate pressure measurement, where the readings exercise an important influence in determining the results of a test. Examples of this are the pressures to be obtained in a test of a centrifugal pump or centrifugal compressor, or the initial pressure in a capacity test of a steam turbine. The instructions throughout this chapter are based on such accuracy, and all of the matter given must be attended to, such as that regarding calibration and graduation of gages, quality of gages, and the liquid or gaseous contents of pipes for pressure measurement.

(*b*) Ordinary pressure measurement, where the values required in a test do not vary very rapidly as the pressure is varied, so that a much lower degree of accuracy is required than that referred to in (*a*). An example is the initial pressure in a steam-rate test of a steam turbine. In such cases it should be agreed upon in advance by interested parties as to which of the precautions given in this chapter may be omitted. For instance, it may be agreed to pay no attention to the contents of pipes for

[1] See pamphlet published in June, 1928.

[2] Chapter 1 of Part 2, on "Barometers," was published in pamphlet form in June, 1929.

Chapter 6 of Part 2, on "Tables, Multipliers, and Standards for Barometers, Mercury and Water Columns, and Pressure Measurements," was published in pamphlet form in June, 1929.

[3] Part 3, Chapter 1, "General," Chapter 5, on "Pyrometric Cones," Chapter 6, on "Liquid-in-Glass Thermometers," and Chapter 7, on "Bourdon Tube Thermometers," were published in pamphlet form in March, 1931.

[4] See pamphlet published in January, 1931.

[5] See pamphlet published in December, 1930.

[6] See pamphlet published in April, 1931.

[7] See pamphlet published in January, 1931.

[8] Chapter 1 of Part 21, on "Condenser Leakage Tests," was published in pamphlet form in November, 1928.

pressure measurement, or to use pressure gages with a lower degree of accuracy than that specified.

(*c*) Incidental pressure measurement, where the readings are not used in obtaining the results of a test, but are taken merely to give a qualitative idea of the operation of the apparatus. An example is the initial pressure on a steam turbine driving a centrifugal pump, when the pump only and not the turbine is being tested. In such cases, if casual inspection seems to denote that the pressure is being indicated in a satisfactory way, no further attention need be paid to the indicator. However, this should be agreed to in advance of the test.

5 *Static Pressure* also exists in the midst of a body of fluid at a distance from a wall. For fluid at rest, or flowing in a conduit with parallel sides of sufficient length to insure undisturbed flow, static pressure is the same throughout each horizontal surface in the midst of the fluid as well as at any static hole in the wall at this surface.

The static pressure in the midst of a body of fluid at rest may be obtained by means of any pipe or tube having an opening at the point in question. The static pressure in the midst of fluid moving in a straight conduit of sufficient length may be obtained by means of a tube with a special construction at the end called a *Static Tube* (described in Pars. 32 to 37), which shall be carefully aligned, with respect to the direction of flow. However, the use of a *Static Hole* in a vessel or conduit wall is usually preferable to the measurement of Static Pressure in the midst of the fluid.

6 In case fluid is flowing in curved paths, such as near elbows, in the neighborhood of surfaces not plane, or in the case of vortices, eddies, or turbulences, force manifested by pressure exists to change the direction of motion of the fluid. In other words, the so-called centrifugal force of fluid moving in curved paths affects the pressure. The static pressure used herein is that in which an engineer is usually interested, and is *not concerned with such occurrences*. Care must be taken to locate static holes and impact tubes as specified in the following, so that pressure measurements are never affected by curved paths. Straight pipe as specified in Par. 23 or guide vanes as shown in Instruments and Apparatus, Part IV, Chapter 5, Par. 93 and Fig. 19, are often necessary.

7 *Total Pressure* is greater in absolute value than Static Pressure by an amount equivalent to the energy represented by the velocity of flow. It is exactly defined by the statement that frictionless, free expansion or isentropic expansion from fluid at rest with a pressure equal to the Total Pressure, into a region with pressure equal to the static pressure, will produce the existing velocity.

8 Total Pressure is measured by use of an open-ended tube pointing into the stream, called an Impact Tube (described in Pars. 38 to 45). The excess of Total Pressure as shown by an Impact Tube, over the Static Pressure, is the exact equivalent of the energy represented by the velocity, being the pressure rise due to perfect conversion of the velocity into pressure, as proved in Par. 43. This difference between Total and Static Pressure is called Impact Pressure, Velocity Pressure, or Pressure Equivalent of Velocity Head, or sometimes simply Velocity Head. When Static Pressure is below atmosphere, Total Pressure is a less amount below atmosphere by the amount of the Velocity Pressure.

9 When measurement is made of the pressure of fluid flowing in a conduit, Total Pressure is often the value required rather than Static Pressure. Such cases are given in Chapter 6, Pars. 35 to 37.

10 Measurement of Total Pressure, when it is required, may be made by use of an Impact Tube as already mentioned, or by measurement of Static Pressure, and the algebraic addition of a computed value of Velocity Pressure. The former method is preferable usually because an impact tube is less often subject to errors than a static hole.

11 For an incompressible fluid, or for gas or steam flowing at low velocities, the Velocity Pressure, expressed as the height of a column of fluid in feet, is numerically equal to the velocity head, $V^2/2g$. General formulas for the computation of Velocity Pressure or Pressure Equivalent of Velocity Head From Flow Rate are given in Chapter 6, Pars. 28 to 34.

12 Gage Pressure and Absolute Pressure are fully explained in Chapter 1, Pars. 1 to 3. Static and Total Pressures, as usually read, are gage pressures or pressures above atmospheric pressure or Barometric Pressure. However, the values used most often in engineering work are Absolute Static Pressures or Absolute Total Pressures, obtained by adding algebraically the Barometric Pressure and the Gage Pressure readings.

13 *Pulsating Pressure* often occurs in conduits connected to reciprocating engines, reciprocating pumps, reciprocating compressors, etc., and its accurate measurement is a source of great difficulty. In most cases the pressure may be measured at a point in the main line where the pulsations have been reduced to a negligible value. This may be accomplished by measurement of the pressure at a distance from the source of pulsations with suitable corrections (Pars. 14 to 19) for the difference of pressure between the point where the pressure is desired but where it cannot be measured on account of large pulsations, and the point at a distance where the pulsations are sufficiently small to permit pressure measurement. This may be combined with use of tanks or receivers of suitable size for a gas, and air chambers for a liquid. There also should be appreciable throttling in the main line in any part of a system devoted to flow measurement only. See Instruments and Apparatus, Part 5, Section IV, Par. 96, for further data for case of Flow Measurement. The arrangement may be considered satisfactory if the maximum and minimum values of the instantaneous pressure do not differ by more than 2 per cent from the mean value. However, there is no easy way to ascertain accurately when this condition is secured, and estimation is usually the only possibility. When pressure pulsations in the main line are thus reduced to what is estimated to be a proper amount, the actual pressure measurement is to be made by damping the fluctuations of the instrument used for measuring the pressure, so that a very slight amount of fluctuation remains which, however, will not interfere with accurate reading. The damping may be accomplished by use of a large chamber in the pipe for pressure measurement, by filling this pipe with liquid or by use of an appreciable length with small diameter, a throttle valve, throttling orifice, or orifice plug in the pipe for pressure measurement immediately adjacent to the instrument (which still shall leave a small fluctuation), or, in case of a mercury gage, by use of a large body of mercury. This latter may be obtained by using long legs, by using a chamber at the bottom of a U-tube, or by using a gage with a single leg and a large reservoir at the base. It is to be noted that the fluctuations of an instrument do not give an accurate index of the actual pressure pulsations, since the instrument and connecting pipe may damp the actual pressure pulsation, or have a natural period so as to magnify it. In reading a fluctuating instrument, read the maximum and the minimum and compute the average rather than try to read the average. None of the preceding matter gives a means for obtaining the average value of a pulsating pressure with certainty. In cases where accuracy is necessary, the only thing which can be done is to measure the instantaneous pressures by use of a steam-engine indicator, with its drum moving in synchronism with the reciprocations which cause the pulsation, or with a paper roll with continuous uniform motion.

Chapter 3—Pipes for Pressure Measurement

CONTENTS

	Paragraph
General	1
Screwed Pipe for Pressure Measurement	3
Tubing for Pressure Measurement	7
Bleeders	11
Size, Slope, and Contents of Pipes	13
Corrections	18

GENERAL

1 This chapter gives instructions for piping between a main carrying a static-pressure hole, static tube, or impact tube (which must be arranged as described in Chapter 2) and a gage or pressure-measuring instrument (described in Chapters 4 and 5). The items specified are the size and type of pipe, the tightness, and the contents with respect to gas and liquid, bubbles, etc., for various pressures and fluids, all for *accurate pressure measurement* as defined in Chapter 2, Par. 4*a*. For *ordinary or incidental pressure measurement* (Chapter 2, Pars. 4*b* and 4*c*) agreement may be had in advance of a test to omit some or all of the precautions herein specified.

2 A slight flow due to a minute leak along a small-diameter pipe gives a surprising pressure drop, and often causes large errors in the pressure measurement. The remedy is to have a pressure pipe made of, at the least, $^1/_2$-in.-inside-diameter or $^1/_2$-in. standard pipe in spite of which the pipe should be tight. A tight pipe theoretically may be of small size, but it is the best practice to have the pipe large as well as tight. The average mechanic will not run a pressure line which is tight unless there is engineering supervision.

SCREWED PIPE FOR PRESSURE MEASUREMENT

3 The pipe may be $^1/_4$-, $^1/_2$-, $^3/_4$-, or 1-in. standard brass or iron pipe. One-eighth-inch pipe shall never be used under any circumstances, because it is difficult to make airtight and because liquid in it drains poorly. The pipe shall be assembled with a pipe-thread compound such as shellac, red lead, white lead, glycerine and litharge, etc., applied to male joints, taking particular pains to make the line tight without plugging it with excess compound.

4 *Test for Tightness of a Screwed Pipe Not Filled With Liquid.* There shall be either a short section of rubber tubing, or a valve with the side carrying its gland faced away from the main, as close as possible to the main whose pressure is being measured. With the pressure-measuring instrument connected, a pressure or vacuum shall be put on the line at least 10 in. of mercury different from atmosphere. Then the valve shall be closed, or the rubber tubing closed with a pinchcock or by kinking, or the rubber tubing disconnected and the pipe plugged so as to trap pressure or vacuum in the line. The instrument will hold its reading if the line is tight, or gradually return to zero if not. Pressure or vacuum may be put on the line by closing the valve when the regular pressure or vacuum is on, or by disconnecting at the rubber tube and blowing or sucking on the line with the mouth or a pump and then plugging the end. In case of a differential gage with two pipe lines, both of course must be tested. If valves are used on a differential line to hold the regular pressure or vacuum for the tightness test (and the line is not equipped with an equalizing valve), the valves must be closed cautiously and in unison to avoid excessive pressure on the differential gage. Differential gages are often equipped with a connection between the two pressure lines, called a "bypass," "cross-over" or "equalizer." A single valve in such a line is never certain to be tight, and there shall always be used two valves with a test opening between, which shall be carefully inspected for leaks when the two valves are closed.

5 Experience with the foregoing-mentioned test indicates that a leak will be found in the pipe for pressure measurement in a great many cases, as shown by the return of the instrument reading toward zero. Work must be done on the line until a test shows that the instrument holds its reading steadily.

6 *Elimination of Leaks.* If a pipe carries a vacuum, leaks may be stopped by painting over the pipe and joints with shellac, asphaltum, varnish, or lacquer, while under vacuum.

If a pipe carries gaseous pressure, leaks may be located by painting over the pipe and joints with a small brush, and watching for bubbles. For air or gas the painting is done with soapsuds, and for steam, with thick cylinder oil.

If a pipe carries liquid at more than atmospheric pressure, or low-pressure steam which will condense, leaks may be located by careful inspection.

TUBING FO R PRESSURE MEASUREMENT

7 *Rubber Tubing.* The rubber tubing shall not be less than $^1/_4$ in. inside diameter, with a wall not less than $^1/_{16}$ in. thick. Thicker walls are preferable and must of course be suited to the pressure. The rubber shall be "live," that is, perfectly elastic. Hard, old, or brittle rubber shall not be used because it is often leaky. This limitation restricts rubber tubing to temporary set-ups. Rubber tubing is usually slipped on metal nipples which shall have a diameter appreciably greater than the inside diameter of the tubing. For pressures greater than 1 lb. per sq. in., the tubing is preferably slipped on the nipples with shellac. For pressures greater than 10 lb. per sq. in., the tubing is preferably retained by a wire wrapped around and tightened with pliers, or by means of a clamp. Rubber tubing, if used for vacuum, shall always have heavy walls. A rubber tube which collapses when vacuum is applied shall never be used.

8 *Copper Tubing.* This may be $^1/_4$ to $^3/_4$ in. inside diameter, with brass-tube or compression couplings. Sizes less than $^1/_2$ in. o.d. shall not be used unless there is special agreement between all interested parties. Pipe and ferrules shall be seen to be perfect by careful examination before the pipe for pressure measurement is connected. The tightening up of the ferrules shall be carefully checked. In using copper tubing with superheated steam, especial care must be taken to see that it contains water and not steam.

9 *Glass Tubing.* Piping for measurement of vacua or pressures up to about 20 lb. per sq. in. may be of $^1/_4$-in.-inside-diameter glass tubing with rubber tubing connecting the joints and forming the bends. This gives positive knowledge regarding liquid or gas pockets, so that other precautions may be waived. It is a very inexpensive and convenient system, and is used exclusively for low pressures by some engineers. For permanent set-ups, rubber tubing is objectionable and the glass may be welded.

10 Careful inspection is usually sufficient to insure tightness of rubber, copper, or glass tubing for pressure measurement. However, with gaseous contents, it is sometimes desirable to have a nipple with a section of rubber tubing at the main, which is removed and plugged for the tightness test specified in Par. 4. The slope of rubber, copper, or glass tube must be carefully established as indicated in Pars. 16–17 and not left with loops, traps, or pockets.

SIZE, SLOPE, AND CONTENTS OF PIPES

14 *Contents of Pipes.* The pipe contents definitely shall be planned and care taken as specified in the following to insure these contents. Three cases arise, with pipe contents indifferent, gaseous, or liquid, and these are discussed in the succeeding paragraphs. Diagrams are given for the last two cases in Figs. 1 and 2,[9] respectively.

[9] Not reproduced here.

Engineering and Industrial Standardization

Standardization of Clean Coal Is Requested[1]

DURING the past few years there has been a tremendous increase in the amount of prepared, cleaned, or treated bituminous coal shipped to the consumer. The anthracite industry has long had a commercial cleaning standard for their prepared coal limiting for each size the amount of oversize and undersize allowable, and the quantity of visible bone and slate in the coal as shipped to the consumer. It is proposed to form a similar standard for prepared, cleaned, or treated bituminous coal.

It should be emphasized that the amount of ash in the coal has no bearing on the proposed standard. The whole question is as to the allowable amount of foreign matter and the range of sizes in a car of coal that is supposed to have been treated. To put the question in another way: Is it not for the best interests of the bituminous-coal industry to establish a reasonable standard of preparation that shall keep and build up the reputation of prepared bituminous coal to the consumer? The proposed standardization of clean bituminous coal is in reality a question of arriving at commercial compromises between manufacturers of cleaning equipment, coal operators, and coal consumers.

There is no particular relationship between this project and the classification of coal, and furthermore, in view of the conflicting commercial interests that will come into evidence on the clean-coal standardization, it would probably be better to separate this work entirely from coal classification.

Howard N. Eavenson, chairman of the Coal Division of the Institute of Mining Engineers, has written as follows in regard to the desirability of setting up such standards:

> For some time discussion has been going on in the bituminous-coal business about the meaning of "clean" coal. Most coal mined and shipped has had no preparation other than casual inspection and separation of the larger impurities in the mine by the loader; a large percentage, in addition to this, has the coal screened at the tipple and certain parts of it spread on picking tables and cleaned by hand; a smaller but rapidly increasing percentage is being cleaned by mechanical processes, either wet or dry, this treatment usually being of the sizes not cleaned by hand, although sometimes all of it is mechanically cleaned.
>
> When coal thus treated is sold it is all sold as "clean" coal, while in some sizes of some coals there may be 0.5 per cent of pieces of impurities, while others may contain 4 per cent. The smaller amount may be the absolute minimum which it is possible to reach, while the larger one depends upon the methods and management used. The amount of impurities necessarily present will vary with the sizes of coal, being usually greater in the smaller sizes.
>
> It is obvious that the mine shipping "clean" coal on the minimum impurity basis is handicapped in competing with one shipping a larger amount, although both products may have been cleaned. In these days of price competition all of these items count, and an agreed-upon basis will be of help not only to the shipper but also to the consumer, who will then for the first time know what he may expect when he buys "clean" coal and will have a standard by which he can measure it.

The American Institute of Mining and Metallurgical Engineers has now requested that a project looking to the establishment of "standards for clean bituminous coal" be instituted under the procedure of the A.S.A. Although such a standard would appear to be a departure in national standardization activities, it is actually similar in its aims to standards for metal and other products which specify maximum percentages of impurities.

The question of the initiation of this work will be submitted to the Standards Council at an early date, and, if approved by the Council, work will soon after be undertaken by a technical committee.

[1] Abstracted from the May, 1931, issue of the *A.S.A. Bulletin.*

Standardization a Recognized Means of Stabilizing Employment[2]

STANDARDIZATION of industrial products permitting manufacture to stock was pointed out as an important means of stabilizing employment during periods of seasonal and cyclical depressions by the American section of the International Chamber of Commerce in a recent report on employment regularization. The report was prepared by a committee of six outstanding business executives for submittal to the International Chamber.

> Even though it may be impossible accurately to predict the anticipated volume of sales a year in advance [the report states], it is still practicable to minimize periodic fluctuations in production through manufacturing for stock. This device, of course, can be applied only in the manufacture of standardized products. It is peculiarly well adapted to the production of articles which are not subject to rapid deterioration, obsolescence, or style changes.

The stabilizing influence of industrial standardization has been frequently pointed out by the American Standards Association and other bodies. Perhaps the most notable example of stabilization of employment in a plant producing a standardized product is the National Lamp Works of the General Electric Company, where 50 weeks of work during 1931 were guaranteed by the management to employees of not less than two years' service with the company.

Commenting on the action of the General Electric Company, Gerard Swope, president of the company, said:

> Stabilization of employment is much simpler in those departments where the product has been standardized and where there is less risk of obsolescence and deterioration. The product of the incandescent-lamp department is notably one of these. The plan for a guarantee of work under certain conditions is offered as a result of the stabilization of production and employment in the incandescent-lamp department. It is hoped that the plan may be continued from year to year, possibly with modifications resulting from experience.

Although the electric lamp represents a degree of standardization which cannot be achieved for many products, almost all manufacturing industries produce many parts which, with proper standardization, could be manufactured to stock during periods of depression, even in cases where the assembled product as a whole cannot be standardized.

A survey made last year by the Committee on Stabilization of Industry for the Prevention of Unemployment, appointed by Governor Franklin D. Roosevelt of New York State, provided evidence that manufacture to stock as a means of helping to stabilize employment is already coming into wide use. Of 598 firms which replied to the committee's inquiries, 292 had some plan of stabilization in operation. Of these, 66 reported manufacture to stock as the means employed. Part-time em-

[2] Reproduced from the May, 1931, issue of the *A.S.A. Bulletin.*

ployment in operation in 157 plants was the only plan more extensively used. Only seven firms reported definite standardization programs.

In its comment on the survey the committee said:

Manufacturing for stock consists of making up goods against anticipated, not standing, orders. This supply is set aside to be drawn upon as orders are filled. Such a procedure is possible with standardized goods and works especially well when the product is also highly seasonal, since it permits fairly even production from month to month. Some firms balanced their staple and seasonal lines by stocking the standard brands in the dull season and making the variable items in the active period. In general, though, the concerns made stock simply on the general prospects of business continuing about the same from one year to another, and did not base such production upon careful estimates of future business founded upon past and present records. Therefore a sudden change affects them more adversely than factories watching the market carefully and controlling production accordingly. The latter method makes manufacturing for stock an integral part of forward planning. . . .

Attention to the products themselves raises the question of standardizing, diversifying, and supplementing the regular articles. Standardization consists of making all the items conform to a limited number of specifications regarding their physical qualities such as size, shape, style, or color. This simplifies the variety of goods to be manufactured, thus eliminating some processes in production and permitting stock to be made in advance of orders. Only a very few firms reported that they had reduced the number of sizes, styles, colors, or other variations in products. Firms that did standardize felt more secure in building up stock, and had greater success in obtaining early orders. Attempts to establish such a procedure with goods that are stylistic met with more difficulty. Clothing is an outstanding example of this type, but even in this field two companies had made definite progress. Such a program necessarily includes educating the consumer to accept the changes.

A.S.M.E. Boiler Code Committee Work

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Below are given records of the interpretations of the Committee in Cases Nos. 661 (reopened) and 674, as formulated at the meeting on April 24, 1931, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

CASE NO. 661 (REOPENED)

Inquiry: a Is it permissible to make the cylindrical portion of the furnace of an internally fired boiler of lap-welded pipe which conforms to the Code specifications, or of firebox-steel plate with an autogenous-welded longitudinal joint? It is to be noted that in order to maintain uniform spacing of tubes, it will be necessary to locate one row of tube holes through or adjacent to the weld.

b Is it permissible to attach the dished head to the cylindrical portion of the furnace by autogenous welding?

c By what method may the strength of the cylindrical furnace, which is in compression, be computed in order to meet the Code requirements? Is it permissible to compute the allowable working pressure by Par. P-240 and decrease this in proportion to the efficiency of the plate along a longitudinal line of holes?

Reply: a The furnace in the boiler referred to may, in accordance with Par. P-9 of the Code, be formed of lap-welded pipe, or if it is cylindrical so that no cross-strains tending to induce tension stress develop in the longitudinal joint, it is the opinion of the Committee that welding will not conflict with the requirements of Par. P-186.

b The Code does not prohibit this method of construction.

c The maximum allowable working pressure for a furnace of this particular type may be calculated by the Adamson ring formula as given in Par. P-242 and the allowable working pressure decreased in proportion to the efficiency of the plate along a longitudinal line of holes. As the tubes are rolled into holes in the furnace sheet, the inside diameter of the tubes may be used in the deductions for metal removed in computing the efficiency of the longitudinal joint.

CASE NO. 674

Inquiry: Will a steam gage for use on low-pressure steam heating boilers conform to Pars. H-56 and H-109 of the Code, if the dial indicator movement is so designed that the movement of the pointer is over only a quadrant of a complete circle and it would be manifestly impossible to locate a stop pin at a minimum of 300 deg. of the circumference from the zero point?

Reply: It is the opinion of the Committee that the combination thermometer and pressure gage described does not conform to Pars. H-55, H-56, H-108 and H-109 of the Code, in that there is no stop pin at the zero point or at the maximum pressure point; because the pressure scale does not indicate $1^1/_2$ times the maximum allowable working pressure for water heating systems; and because the travel of the pointer from the zero point to the maximum pressure point is less than 300 deg. of the dial circumference. A revision of the Code to cover the above is under consideration.

Correspondence

CONTRIBUTIONS to the Correspondence Department of Mechanical Engineering are solicited. Contributions particularly welcomed at all times are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on its activities or policies in Research and Standardization.

The Cottonseed-Oil Industry

TO THE EDITOR:

In the May issue of MECHANICAL ENGINEERING Professors Carpenter and Holdridge present the cottonseed-oil industry in quite a concise and clear manner. The writer will not discuss the historical section of their paper but will add some facts gained through his twenty years of constant work in and with the oil mills.

One of the greatest curses of the cotton-oil business has been the practice of buying seed without regard to grade. Prior to two years ago, all seed, except visibly badly damaged seed, was accepted by the mills at the same value, whereas apparently sound prime seed may easily vary more than 20 per cent in value. There are two outstanding reasons for not having graded seed in the past, the first being the keen competition for the seed, the second, the difficulty of determining the grade. So far, the only possible method of determining grade is by chemical analysis, which is troublesome and expensive. To date the oil mills have accepted seed from gins continuously where all the sand and other trash cleaned from the cotton as ginned was spouted back into the seed, even though this is in direct violation of the law in some of the states.

Some seed received at the oil mills contain more than 20 per cent of moisture. Under average climatic conditions at the mills the highest moisture content the seed may contain to be safely stored without having some method of cooling is approximately 10 per cent. A very few of the larger mills have steam driers for drying high-moisture seed before storing it. Such installations are very costly and also are expensive to operate. Approximately 50 per cent of the mills have no drying or cooling devices whatever, but endeavor to keep stored seed segregated, carrying smaller stocks and, as far as possible, crushing the hot seed first.

All seed contains some free fatty acids, and the percentage cannot be determined, or even remotely estimated, by inspection, but must be chemically determined. So long as the free fatty acids do not exceed approximately 1.8 per cent, the oil will usually refine as prime oil. In some sections of the Cotton Belt the seed rarely ever contains this amount of free fatty acids; in others, however, the seed frequently contain double or treble this amount, when first ginned. In storage, there is a tendency for the free fatty acids to increase with the temperature at all temperatures above freezing.

Just as much total lint per ton of seed may be taken off by passing the seed through linters once as by double or treble series linting. Such lint is commonly known as "mill-run lint," and the United States Department of Commerce report shows that 36 per cent of the total lint produced during the three past years was mill-run lint.

The theory of separation advanced, that hulls without meats are separated by air from hulls with meats adhering thereto, is rather impractical.

Either the single- or double-hulling system, or a combination of the two, is used today in the mills. It is customary at most mills to pass all hulls through some form of beater regardless of the separating system used, to separate any meats left adhering to the hulls.

It is customary at many mills to grind the cottonseed meats as fine as possible through disk mills before rolling them. At practically all mills where this is being done, it seems to improve the preparation of the meats.

There is still in use, in many mills, the older type of batch cooker. Substantially as good cooking has been done with this type of cooker as with the continuous or stack cookers, but it requires more setting space and more attention to operate.

All cooking at present is done at substantially atmospheric pressure. Considerable experimental work has been done under vacuum and also at pressures above atmospheric. The cooking under vacuum produced a lighter-colored oil and cake, but good extraction was not obtained. The higher-pressure cooking darkened the products.

Four thousand pounds per square inch under the press rams is the preferred practice of today, and rather the minimum instead of maximum pressure. Many mills use approximately 4300 lb. regularly, and some as high as 5000 lb., which is equal to 1700 to 2200 lb. per sq. in. on the cake. The time the presses remain standing under the high pressure measures the percentage of oil extracted from the cake, and also has a material bearing on the hardness of the pressed cake.

Since the oil is the most valuable of any of the products from the seed, any improvement producing more oil or a higher quality would be most beneficial.

No one in the business seems to understand thoroughly the condition the meats should be in for the best mechanical extraction. There may yet be found an extraction method much more efficient and economical than any of the chemical or mechanical methods yet devised. The cottonseed-oil business, in the writer's opinion, offers one of the most fertile fields for engineering research and development of any manufacturing business of which he is cognizant.

T. M. FRANCIS.[1]

TO THE EDITOR:

The authors of the paper, "The Cottonseed-Oil Industry," appreciate very much the discussion presented by Mr. Francis. The writer attended the Birmingham meeting and heard Mr. Francis present his ideas At that time it seemed evident that the authors and Mr. Francis were agreed on all matters of importance. However, upon careful study of the written discussion there seem to have been some points in the original paper which were at least misleading.

In that part of the article referring to "separation" the authors did not intend to convey the impression that the air lift on the separators could distinguish between empty hulls and those to which some meats still adhered, but rather to indicate the method by which the hulls were removed from the stream of hulls and meats.

In the case of the diagram indicating the steps followed in the oil mill, beaters are not shown since they were considered a part of the separating apparatus.

With regard to press pressures, it is true that pressures much higher than 4000 lb. per sq. in. under the ram are used. However, experimental data indicate that such pressures often do little more than add to the already excessive mechanical load and increase the hardness of the cake.

Prof. M. K. Thornton, of the Texas Agricultural and Mechanical College, recently made the statement that practically 90 per cent of the oil is extracted from the meats before the high pressure is applied.

Referring to the matter of cooking conditions, one must always keep in mind that it is not the pressure but the temperature under which the meats are cooked that affects results. Of course, high steam pressure will give high temperatures, and consequently result in darkened products.

E. L. CARPENTER.[2]

MODERN technical achievement and scientific thought foreshadow a new economic structure for society in which those with scientific knowledge should exercise a decisive influence upon the major policies of the state as well as upon their administration. If there were, in the House of Commons, half a dozen men with scientific knowledge as well as the ability to place that knowledge before those who represent the community in Parliament these people could rule the world.—Sir Richard Gregory before the Society of Chemical Industry, London, April 24, 1931.

---

[1] Consulting Engineer and Specialist in Vegetable-Oil Manufacturing, Birmingham, Ala. Mem. A.S.M.E.

[2] In charge of Engineering Extension, University of Tennessee, Knoxville, Tenn. Assoc-Mem. A.S.M.E. Co-author of paper, under discussion.

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers, and Proceedings of

The American Society of Mechanical Engineers

29 West 39th Street, New York

ROY V. WRIGHT, *President*

ERIK OBERG, *Treasurer* CALVIN W. RICE, *Secretary*

COMMITTEE ON PUBLICATIONS:

F. V. LARKIN, *Chairman* L. C. MORROW

W. H. WINTERROWD S. F. VOORHEES

S. W. DUDLEY

C. E. DAVIES, *Secretary to Publications Committee*

PUBLICATION STAFF:

G. A. STETSON, *Editor*

FREDERICK LASK, *Advertising Manager*

Contributions of interest to the profession are solicited. Communications should be addressed to the Editor.

BY-LAW: The Society shall not be responsible for statements or opinions advanced in papers or . . . . printed in its publications (B2, Par. 3).

Research in Power

OUR contemporary, *Power*, has given excellent evidence of its enterprise in devoting an issue to research in the fields of engineering that it serves. Several articles by research workers well known in engineering circles for their work precede a 27-page tabulation of current research in power and allied fields, grouped under the following headings: boilers, combustion, condensers, corrosion, electrical, feedwater, fluid flow, fuels, heat transfer, heating and ventilation, internal combustion, lubrication, materials, steam prime movers, smoke and dust abatement, thermal, water power, and welding. Six hundred research projects are listed, and for each is given the location and name of the investigator in charge of it, its sponsor, and its present status. In some cases comments on the results are also included. The tabulation is worldwide in scope.

The coordinating effect that this evidently carefully prepared table will have upon research work in power and allied fields is difficult to estimate. Here is a clearing house of information of value not only to research workers, who always run the risk of duplicating the work of others and who always need the help and inspiration to be derived from contacts with others working on similar projects, but also to engineers who are faced with problems upon which they may give or receive important data.

Any one who supposes that most of the problems in the field of power are already solved will have this illusion dispelled by studying the scope and character of the projects listed. What infinite possibilities lie in the future, none can guess. The elements of progress lie in the solution of these projects. Greater economies, modified and improved practices, and new industries will be the fruit of these researches. No one designing, operating, or manufacturing equipment for power plants can afford to neglect the possible effects to his specialty—the beginnings of which are already developing in some laboratory—that these and other researches will have. *Power*, in its issue of May 26, has made it possible for such persons to know what is going on, and who is doing it.

Industrial Preparedness

RECENT announcements in the daily press regarding a reduction in the peace-time military establishment of the United States bring into focus one factor in preparation for national defense which is of supreme importance to engineers and industrialists. Learning an important lesson from the last war, Congress passed the National Defense Act of 1920, which created the office of the Assistant Secretary of War and established his responsibility in the planning and preparedness of industry for emergencies. The office of the Assistant Secretary of War has made splendid progress and has developed plans which will enable the Government to save several months of preparation time, with consequent economy of lives and dollars. The expense of this work is relatively small compared to the amount of money that is being devoted to the training and organization of man-power reserve.

A former public official stated that in the event of attack our citizenry would spring to arms over night. The question of providing arms for them is more difficult, however, as it involves an overturn of industry from peace-time production to the making of material about which it has little information and no manufacturing experience. It is important, therefore, that in any reduction of our military establishment that may be decided upon there shall be no diminution in the planning and the work of industrial preparedness, a preparedness which constitutes our best assurance against attack and is wholly without those provocative elements which are inseparable from large armaments and large military establishments.

S. W. Parr

IN THE death of S. W. Parr, chemist and metallurgist, engineers have lost a valued authority in the science upon which boiler-room practice is based. To Professor Parr and his associates at the University of Illinois, engineers owe much of their knowledge of the analysis and composition of fuels, and the chemistry of combustion and boiler-water treatment. The Parr calorimeter for determining the heating value of coal and other fuels, devised by him, has long been used in this country and abroad. Much interest has recently been aroused by Professor Parr's studies of the so-called caustic embrittlement of boiler steel. He was a valued member of the Joint Research Committee on Boiler Feedwater Studies, bringing to the work and viewpoint of that committee the knowledge and experience of a chemist who thought in terms of an engineering application of fundamental principles.

Engineering draws its knowledge and practices from the field of science and from the industrial arts and technologies. It makes practical use of scientific facts and principles, and by this means extends industrial developments for the enrichment of material welfare. Scientists of Professor Parr's type find service to mankind not unworthy of them in their high pursuits. To make permanent contributions to scientific knowledge is an achievement of high order, but to apply them as well to immediate and practical uses deserves especial praise. Professor Parr was one of those who have enabled engineers to brush the dust of ignorance and empiricism from their practices and illuminate them with the lamp of science.

Every One Can Help

THE New York *Times* and the *New Yorker* call attention to some aspects of the present scene that we have frequently commented upon. The *Times* reports the results of examinations of various automobile trucks which revealed the fact that they were so badly out of repair as to be unnecessarily noisy. The *New Yorker* finds a small degree of satisfaction in the destruction by fire of fifty 10-ton trucks, which it hails as a reduction of city noise to the extent of the nuisance that just that number of 10-ton trucks account for.

The mitigation of nuisances that spring from the contributions engineering has made to the complexities and annoyances of modern life should constantly engage the thoughtful attention of engineers. Safety, air pollution, and noise abatement are factors in design and operation that are as important in the larger aspects of mechanical devices as is the proper functioning of the devices. The ecstasy of the creator who looks upon his work and finds it good should not dull his esthetic sensibilities to the nuisance it provokes. It should not be necessary to excuse a smoking chimney on the ground that the wheels of industry are turning, or a maimed body by attributing industrial accidents to carelessness, or a noisy motor bus or truck by saying that transportation must be provided at any cost. For these nuisances engineers are to blame; for their mitigation society holds us responsible. Perfect safety, the unpolluted atmosphere and waters of primeval regions, the restful quiet of a lonely countryside, are too Utopian for attainment. They would cost more than society is willing to pay, and could be preserved only with extreme vigilance. But every engineer can insist on practices that will go a long way toward a marked improvement in existing conditions if he will have these factors in mind when he designs and operates mechanical devices.

British Steel

THE British Steel Makers' Association have agreed to roll on all their products a national trademark showing that the product is British steel. This signifies a growing tendency toward doing business on a national scale. There was a time when each manufacturer stood by himself, seeking his own markets and making his own products. Then there was a period of consolidations and mergers, as a result of which the number of manufacturers decreased very greatly. The merged concern, however, still carried on business along the same old ways of individualistic control. In foreign business, some governments were not averse to assisting in an unobtrusive way their nationals to get trade, but openly this was done only in such industrially and politically backward countries as China and Turkey. Of late, however, the tendency has been either toward frank competition between nation and nation, or to the formation of cartels by which markets are divided between several nations. The recent discussion in regard to exchanging the manufactured products of western Europe for the agricultural products of eastern Europe represents an effort to arrange a huge trade deal under the diplomatic aegis.

Another tendency is for governments openly to assist their national groups in obtaining foreign business. Thus the German and Italian governments have already guaranteed sales made by their nationals to the Russian Soviets. Only time can show the effect of such entries of great national bodies into trade. Apparently, however, the tendency has within it a germ making for future growth.

It may be mentioned in this connection that as a result of the British law which two generations ago made it compulsory to indicate on foreign products the country of their origin, the famous "Made in Germany" label eventually grew from a token of cheap, rather unsatisfactory goods into one that sold them on their merits. Whether or not a similar mark reading "British Steel" will also come to connote high quality remains to be seen, and there is every likelihood to believe that on this factor of quality combined with competitive prices depends the success of the movement in question.

Aeronautical Developments

DEVELOPMENTS in aeronautics have in recent weeks been coming thick and fast. The most spectacular one was unquestionably the air maneuvers of the U. S. Army, in May, in the course of which 672 planes were flown according to a prearranged schedule from Dayton to Chicago, thence to New York and Boston, and finally to Washington. The fact that this was done exactly as planned and that so large a number of planes flew the distance indicated without the loss of a single life, indicates both the high state of development of the U. S. Army aeronautics and the high state of development of the art of aviation itself.

Another important development was the Baltimore meeting, May 12 to 14, of A.S.M.E. Aeronautic Division, at which account was taken of the apparently growing recognition of the value of so-called "blind" flying, or flying by instruments only. This involves not only the matter of training for "blind" flying, a subject of considerable difficulty in itself, but also the development of instruments that will make it possible.

Two things may be reasonably expected from the efforts being made to introduce "blind" flying. One is the increased safety which will result from the ability of fliers to handle their craft better than now in complete darkness and fog. The second and probably even more important effect will be the greater attention that will be given to the pilot and his physiology and psychology. It may be stated without much fear of contradiction that although an enormous amount of research and inventive activity is being directed toward the improvement of planes, engines, and equipment, the human factor—the pilot—has been comparatively neglected; and even the training of pilots has not received the amount of attention it deserves, except, perhaps, in the Army and Navy, and even there probably not to the maximum possible effect.

Fifteen technical sessions were held at Baltimore and 50 papers were presented. There were five sessions on design and construction problems, three on engines, one on propellers, one on air transport, one on training and navigation, one on instruments, one on aircraft communication, one on airships, and one on airports and management. The quality of the material presented in the papers and discussions was of a high order, indicative of the extensive study to which all problems pertaining to aeronautics have been subjected.

The leading article of this month's issue of MECHANICAL ENGINEERING is a portion of the address that Bernt Balchen, chief pilot of the Byrd Antarctic Expedition, delivered at Baltimore. More than one thousand persons turned out to hear Lieutenant Balchen's unique address.

Noted speakers at the banquet included Senator Tydings, Senator Hiram Bingham, Admiral W. A. Moffett, and Roy V. Wright.

Improved Library Service

A STATEMENT concerning the United Engineering Societies Library in New York, suggests many ways in which greater service might be rendered if the means were provided. It is appropriate to summarize this statement and to invite comment upon it. Not only engineers who are located in New York who

use the library most effectively, and those who avail themselves of its excellent services by mail, but also those who have never been its patrons but who support it through their society dues can be helpful to the Librarian and the Library Board by offering their comments and suggestions. Excerpts from the statement follow.

"The Library is the natural clearing house for all engineering and chemical research. In time its position should be such that research workers will not only see that it has copies of the printed papers, but will provide typewritten reports in such cases where they are not printed.

"One important need that cannot be satisfactorily met at present is the need for a larger lending collection. To meet the desires of the profession, it will be necessary to have several copies of many books, instead of but one as at present. Duplication of important books, especially foreign ones that cannot be obtained quickly, would be greatly appreciated by thousands of workers.

"More could be done in the way of indexing, and the saving in time as a result of such indexing would make it a good investment for engineers and industry. In view of the fact that here as in other directions the expenditures are made by the Library to conserve time and expense for others, the amount of justifiable expenditure is always a serious problem.

"There is also need for some institution to take the initiative in studying the library requirements of the profession, coordinating the facilities and determining what more is necessary. It seems reasonable to suppose that coordination might be effected between the libraries that now exist, with advantages for all. It might be possible to unite many of them in a single system, somewhat like the usual municipal system of a central library with branches. The Library Board has considered the possibilities of such a union of effort with interest, but has not had funds with which to survey the problem systematically."

What improved service do readers of MECHANICAL ENGINEERING want from the Engineering Societies Library? We shall be glad to convey all comments to the Library Board.

Work for the Blind

THE World Conference on Work for the Blind was held in New York in April, 1931. The subject is of interest to engineers from two points of view: first, because of the natural sympathy they have for those who are deprived of one of the most important senses and, second, because they are largely relied on to find methods of employing the blind in the industries.

Looking over such systematic efforts as have been made in this direction, little is seen concerning which to be cheerful.

According to a report by Ernst Retsler on what has been done in Sweden, school attendance was made obligatory for all blind children more than thirty years ago. They receive education free of charge at schools established by order of Parliament. The great majority of male blind pupils are taught handicrafts specially adapted for the blind, while female pupils are taught sewing and other forms of needlework, as well as cooking and allied domestic occupations. Later, some of its pupils take up special courses of training, for instance in massage, but these are only sporadic exceptions to the rule. Save in isolated cases it has not been found feasible to employ blind persons in factories in Sweden.

Brushmaking, which is the principal handicraft for blind men, is now being done more and more by machinery, the product of which is successfully competing with domestic production. Some of the blind have managed to attain positions of independence, but with the majority the principal difficulty has been in selling the articles they have made.

In England, according to S. W. Starling, a great deal of research has been done during recent years in the hope of extending the field of usefulness of the blind. The difficulty is that, while suitable occupations or processes of manufacture can be found for the sightless, obstacles of one kind or another are discovered which prevent persons thus affected from following them. The result is that the field of employment for the blind in England is comparatively limited and resolves itself generally into occupations which require manual dexterity.

A list of such possible occupations is given by Mr. Starling which includes in addition to the usual basketmaking, brushmaking, etc., the making of bags for coal, gas-cylinder covers, ship fend-offs; and for women, machine knitting. One shop making knitting needles has been organized for partially blind men. The conclusion arrived at is that none of the occupations listed provide enough for the worker to live on.

In Japan a special tax has long been levied throughout the country for the benefit of the blind. The blind have been trained in such occupations as massage, shampooing, and Japanese music, particularly that of stringed instruments. In the old days some of the blind developed special arts and taught them to other blind persons in schools for the purpose. However, because of lack of jobs, many who have their sight have entered into the occupations which formerly were considered exclusively those of the blind; nevertheless, though they no longer monopolize them, massage, acupuncture—a Japanese method of treating diseases by thrusting needles into the body—and music are still the most important vocations for those who cannot see.

It would appear, therefore, that with a few exceptions, none of the countries referred to above have found ways to make the blind self-supporting. The only cheerful feature of the situation brought out by the conference is that through a better understanding of the causes of blindness and increased prophylaxis the number of blind is rapidly decreasing.

Obviously there is need for greater development in the training of the blind. Studies made in this country indicate that there are a sufficient number of operations that blind persons might be taught to do successfully to take care of all of those so afflicted. On these operations they could be employed more constructively and could make larger earnings than in the handicrafts for which they have been trained for a great many years.

To bring this about would necessitate a change in the attitude of industrial management toward the blind through education, and the design and manufacture of special equipment which fall within the realm of the mechanical engineer.

Spengler—Prophet of Despair

A NEW YORK *Herald-Tribune* dispatch, dated at Berlin, May 7, reports the melancholy event of an address made by Oswald Spengler at the Deutsche Museum in Munich—an institution which thousands of American engineers have visited with interest and delight.

The illustrious author, according to the report, predicted that a "tragic end to the entire development of the human race is inevitable. . . . . The idea of progress cherished in the nineteenth century has become shipwrecked. Every birth is followed by death. Civilizations come and go, and world history does not consist of perpetual progress, but of a ceaseless struggle of ups and downs. . . . . The final epoch of Western European civilization has been reached. Artificial machinery has more and more removed man from nature, and nature is taking a fearful revenge by making man the slave of his own machines." There is only one thing man can do, and that is to "stand heroically at his post, fight on, and not fold his hands in resignation before his dismal future."

We are told that his address made his distinguished audience of German and foreign scientists gloomy; and that Hjalmar Schacht, former president of the Reichsbank, who presided over the gathering, sought to cheer them by speaking of the "divine mission of mankind."

Spengler is no shallow, temperamental pessimist. His "Decline of the West" is a powerful, magnificently poetic book. It is not unworthy of being classed as the greatest literary product which the twentieth century has as yet produced.

His thesis is to the effect that civilizations have a typical life history; that the course of this history has been invariable throughout the seven historical cultures of which we have knowledge; and that the present civilization of Western Europe has passed its climax, and has entered upon its long, unfruitful, and inevitable decline. The mass of evidence he brings to bear to uphold this thesis is terrifying in its variety and effectiveness.

The scheme Spengler sets up is too systematic, too compact and well-rounded, to be true in all its details, if we are to trust our experience in any other of our successful analyses. The homologies cannot be *quite* so perfect, the predictions *quite* so sure, as he would have us believe. But it is difficult for any one of reasonable intelligence and a fairly open mind to read through the two volumes, with all their dim metaphysics and enormous multiplicity of comparative detail, without being strongly led to the belief that Spengler has observed and reported truly on the large aspects of history.

There *have* been several more or less separate cultures, each ending in an elaborate civilization, which slipped from power to decadence. Our own culture *has* followed the typical path to the civilization of this time; and has at this moment reached the point which in past civilizations has marked the apex—the point beyond which the slow, imperceptible forces of dissolution begin their work.

Indeed, in those rare moments when we find ourselves freed of wish rationalizations and systematized desires, our very common sense asks us if there is any particular reason (except that it seems incredible on the near view) why our civilization should not in its turn rise, flourish, and fall, as have all others.

Spengler himself leaves some loopholes in the remorseless walls between which he would constrain our course. Of these, two are important. This civilization, first and alone of all those which have risen and fallen, has attained to an effective working control of the material world—of the matter and forces with which nature surrounds us. In addition there has been given to this civilization the sense of history—the ability to see simultaneously the contemporary scene and the older circumstances from which it sprung—to place in their proper relations with the past life of the world the conditions and problems which face us today.

What do these admissions mean if not that we approach the immemorial crisis with new resources and new aptitudes? And perhaps, for this reason, with new and justifiable hopes?

By what logic, furthermore, does he divorce our mechanized and complicated civilization from the normal development of nature? Is it alien to it, or antagonistic to it? Perhaps the first lung fishes who scrambled out on to the slimy mud banks and were forced back into their ancestral element again and again, might have wondered if they were not in conflict with "nature." That they finally succeeded, in spite of that, in adapting themselves to a normal terrestrial life, is evidenced by our own existence.

There are a thousand evidences to encourage us in the belief that there is no hopeless, foreordained disaster toward which our steps are being directed. For the first time in history Man faces his destiny with self-consciousness, determination, and the effective weapon of the scientific method. If this time he succeeds in mastering his fate, it will be due in part to these new resources. But it will be in part due, as well, to his clear conception of the historical process of which he finds himself a part; and for that conception a large share of credit must be given to Oswald Spengler, self-appointed Prophet of Despair!

RALPH E. FLANDERS

Engineering and Economics at Hartford

CONSPICUOUS evidence of the close relationship between engineering and economic and social problems was exhibited at the Hartford Meeting, June 1 to 3 of The American Society of Mechanical Engineers. Without abandoning the strictly scientific and technological elements of engineering, the practitioners of the profession are day by day entering broader fields of business, industry, and service to the commonwealth that give them a fuller knowledge of the significance of their own activities and an opportunity to make use of their knowledge and ability in the study of some major problems of organized society. Accused of having been responsible for much of the acceleration of change that has taken place during the past decade, of increasing technological unemployment and obsolescence of industries, processes, and materials as well as the arts and handicrafts, and of overproduction because of the elimination of waste and the improvement in production efficiency, engineers have struck back by pointing out the fact that the failure has been that of those in other important fields to keep abreast of recent progress. Bankers, merchandisers, economists, politicians, and sociologists generally have apparently been unable to provide the vision and leadership necessary to make the possibility of material progress and abundant productive capacity an unalloyed blessing to mankind. From what was said at Hartford, both publicly and in private conversations, the impression is strong that engineers feel themselves unduly criticized, poorly advised, falsely led, and unnecessarily restricted in their beneficient services to humanity through the breakdown of other elements of society over which as yet they have neither authority nor control.

There may be some justification in the opinion held by non-engineers that the engineer would do worse in public life than in his own profession. Indeed, Senator Hiram Bingham, in his Monday evening address, expressed the fear that engineers might overlook the essential individuality of the human elements of which society is composed, should he ever find himself in an important public post.

There was an implication of *laissez faire*—an unconscious admission of impotence to cope with a complex problem—in Senator Bingham's words that is disturbing to the engineer. It must be remembered that engineers have made notable successes in problems involving human relations—failures as well, it is also admitted—and that they are probably closer to the daily lives of large masses of employed persons than are men in most other professions. That they attempt appeals to reason, rather than to emotion, is natural and in keeping with their well-known disposition to act upon carefully ascertained facts and to seek for things and means that an abundant providence has sometimes obscured. It was this spirit that made engineers not content with slow-drying varnishes for automobile finishes, and resulted in the lacquers that have become so popular and cut down so materially the time required for the paint job. Here was no supine folding of hands in the face of a situation that called for study and action, but an agressive attack on the very fundamentals of the problem.

This spirit, is, of course, responsible for the bad grace with which the engineer accepts economic ills. His attitude is not necessarily made bold by ignorance of the intricately woven threads of influence in a delicate fabric of social and economic

relationships. He finds privation an anomaly in the face of overproduction and unemployment, and business stagnation incompatible with willingness to work and human desires unfulfilled. Nor does he counsel surrender of higher standards of living in America in the face of European competition. This prospect he finds, in the words of Ralph E. Flanders, discussing employment stabilization at Hartford, "terrifying to contemplate."

The engineer-employer has, we believe, resisted the impulse to reduce wages. He has exerted supreme efforts to reduce labor costs, while maintaining wage rates. He seeks a better way out, and he feels that perhaps the reductions in the costs of production that he has effected have not always been passed on to the consumer, but have many times been dissipated in increased selling and distribution expenses.

Mr. Howell Cheney, who led the discussion on stabilization of employment, pointed out that wages had been reduced and that further reductions were taking place and would take place until an economic balance was restored. It was his hope that the restoration might come quickly and naturally. Lower costs, he pointed out, might be the result of a reduction of wage rates, of greater efficiency of labor, and of improved processes that eliminate waste. As Mr. Schwab noted in his Iron and Steel Institute speech, good management would make use of the last two methods before it resorted to the first, and with this point of view engineers seem to be sympathetic.

Additional elements of the situation that the engineer views differently from some others are those of replacement of plant and equipment and of improvement in process and product in times of depression. These matters were brought out at Hartford, where it was pointed out that capital expenditures for them, even when previously provided for and immediately available, were being denied at a time when conditions are favorable because of prices, labor, and low production schedules.

The economic phase was taken up also by President Roy V. Wright in his address at the banquet. After a review of the present situation and its implications, he showed that engineers had many obligations and opportunities in helping to find a way out. It was fortunate, he pointed out, that the American Engineering Council had seized the opportunity confronting it by appointing a committee, of which four of the five members belonged to the A.S.M.E., to report on balancing the forces of production, distribution, and consumption.

Turning now to some of the more strictly engineering features of the Hartford Meeting, it must be remarked first of all that the technical papers presented were of a high degree of excellence. The publications of the A.S.M.E. will eventually bring most of them, and the discussion they elicited, to the attention of engineers who were unable to attend the meeting. As an indication of trends in subject-matter, it should be noted that in spite of a 50-paper national aeronautics meeting in May, and a national meeting on applied mechanics in June, there was no absence of papers or interest in these subjects at Hartford. The times of course, are responsible. Aviation is developing rapidly; and the analytical study of design problems is an essential corollary of keen competition and improvements in machinery.

Hartford's industrial roots reach deep into the fertile soil that produced the unique system of interchangeable manufacture, so long characterized as typically American. It was in Hartford that Samuel Colt built his great armory in 1853, in which he manufactured his revolver according to the system he had learned from Eli Whitney. This marked an epoch, says Professor Roe, not only in the history of Hartford but in American manufacturing. Fourteen hundred machines, mostly built on the premises, and tools and fixtures, to the astonishment of contemporary manufacturers, that cost almost as much as the machines themselves, laid the basis for the most economical and accurate production of a high-grade product that the world had ever seen. From this laboratory and training school of early American manufacture came men and ideas and machines that overflowed the boundaries of this shop and became the bases of new industries and of improved technique and craftsmanship.

Engineers attending the Hartford Meeting were privileged to inspect the present works that stand where Colt built his armory, and those of the Pratt & Whitney Company, founded by two of Colt's workmen, Francis A. Pratt and Amos Whitney. Here the tradition of invention and precision in workmanship was fostered in the building of small tools and machine tools, itself becoming another laboratory and training school for later industrial development and generations of creative mechanics. And also were engineers at Hartford afforded the opportunity of inspecting the newest plant of this lineage, the Pratt and Whitney Aircraft Company, where further evidence of ability to manufacture a high-grade product was abundant.

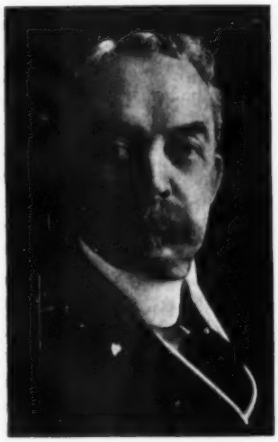
This modern aircraft-engine plant, and its neighbor, the Chance Vought Corporation's plant, exhibit striking similarities and differences. The large, single-storied buildings with abundant roof lighting are thoroughly modern in design and equipment. Inside, however, the activities afford interesting contrasts in materials and methods. In the Chance Vought plant, building airplanes for the U.S. Navy handicraft methods prevail. Wood and fabric are the principal materials. The workman still has his grip on the tool, even in such modern methods of construction as welding, of which beautiful examples are to be seen. In the Pratt & Whitney plant, however, metal predominates, and aside from some hand fitting, special machines with jigs and fixtures and precision tools do all of the work.

One cannot escape the conviction that these manufacturers are in business to stay. The haphazard workmanship and manufacturing methods of the experimental period have vanished in a completely laid-out and carefully planned production system. Precision in workmanship and care in inspection are abundantly exemplified. One's mind runs back to the early revolver, the first product of interchangeable manufacture in this chain, and to the contemplation of the successive stages of improved machine tools, jigs, fixtures, gages, measuring instruments, workmanship, and materials that have alternately been the cause and effect of these remarkable developments. The typewriter, the machine tool, the small tool, the bicycle, automobile, and airplane engine are all part of the history of Hartford's industrial development, each presenting a new challenge to the mechanic's skill, and each bearing in it the seeds of new developments in other fields. Alloy steel, aluminum, magnesium—how different from the materials that lay at the hand of Samuel Colt; and how amazing for his contemplation the sturdy, intricate, and precisely made radial engine in comparison with the cumbersome steam engines of his day! Here in Hartford is epitomized the history of the development of the fine-machine industry from the day of Colt's patent firearm to that of the Wasp and Hornet engines.

The distinct feeling of satisfaction with which one looks back upon the Hartford meeting does credit to the gracious hospitality and effective hard work of the Hartford Section of the A.S.M.E. and its committees who gave such painstaking attention to plans and details. The sense of gratification that is felt after such a meeting arises from the high quality and lack of superficiality that characterize such gatherings. The Monday evening entertainment in the Bushnell Memorial Auditorium, with its program of music and addresses, was typical of what Hartford offered to her guests, and reflected great credit on those responsible for it.

Edward Dean Adams

1846–1931



EDWARD DEAN ADAMS

WIDELY known for his leadership in the project of harnessing Niagara Falls electrically, Edward Dean Adams, engineer-financier, died in New York City, May 20, 1931. Always ready to give the best of himself for friends and public, Mr. Adams was honored for his leadership, broad comprehension, keen analytic ability, and sympathetic interest in all of his many and varied undertakings. At a dinner in his honor in 1925, Dr. W. F. Durand said of him: "A great financier and engineer, an organizer and director of great industrial developments, a patron of libraries, and in a peculiar sense of the great engineering library in New York City, of which the engineering fraternity is so justly proud, a patron of the fine arts and of the sciences in their collective sweep, a patron of, and a participant in, the administration of great museums, a leading spirit in public affairs of wide scope—municipal, state, and national, his life has touched human affairs at many points, and always in a helpful and constructive way."

Referring to the approaching twilight of his life, the address of Mr. Adams at this testimonial dinner closed with the following:

> Welcome, O Friend, draw near,
> With peaceful step and with untroubled breath;
> No gloom, no woe is here,
> But thanks for life, and equal thanks for death.
>
> —CHARLES ELIOT NORTON

Even at his advanced age, 85 years, Mr. Adams was loath to curtail his activities. During his career he was intimately associated with many leaders of finance, railroads, electrical development, and hydroelectric enterprises. During 54 years in business he was a director or officer of more than 40 banks or corporations engaged in transportation, manufacture, power development, or other engineering enterprises. He effected no less than six reorganizations, was chairman of the board of directors of 12 manufacturing, mining, or engineering corporations, served as president of 10 other concerns, and was a voting trustee for three more. Probably most fame came to him from his creation of the Cataract Construction Company and the hydroelectric development at Niagara Falls. For 20 years he served actively as president of the Cataract Construction Company, until the property was turned over to the present company, a work stupendous enough for the lifetime of any one man.

Mr. Adams was a very active member and officer of the Engineering Foundation from its beginning in 1915. He served as vice-chairman from 1915 to 1926, and was made its only honorary member in 1926. Concurrently, he also served as a member and officer of the Library Board. He was awarded the John Fritz Medal in 1926 in recognition of his great achievements as "engineer, financier, scientist, whose vision, courage, and industry made possible the birth at Niagara Falls of hydroelectric power."

Mr. Adams was born in Boston on April 9, 1846, the son of Adoniram Judson Adams and the former Harriet Lincoln Norton. An ancestor was Henry Adams, of Braintree, Mass., who came to this country from Somersetshire, England, in 1638, and whose descendants included two early presidents of the United States, John Adams and John Quincy Adams.

After graduating from Norwich University at Northfield, Vt., in 1864, with the degree of Bachelor of Science, Mr. Adams traveled abroad for a year, spent a year at Massachusetts Institute of Technology, and then became bookkeeper and cashier for T. J. Lee & Hill, Boston stockbrokers. Four years later he joined the banking firm of Richardson, Hill & Company, of Boston, as a partner.

In 1878 he entered the banking house of Winslow, Lanier & Company as a partner. At various times he had business dealings with the late J. Pierpont Morgan. He organized the Northern Pacific Terminal Company of Portland, Ore.; the St. Paul & Northern Pacific Railroad Company, of which he was vice-president from 1883 to 1887; and the New Jersey Junction Railroad Company; reorganized the Central Railroad of New Jersey, and had a part in the reorganization of the New York, Ontario & Western Railroad, the West Shore and Ontario Terminal Company, and affiliated interests.

From 1890 to 1896 Mr. Adams was chairman of the board and president of the American Cotton Oil Company, which he reorganized from the American Cotton Oil Trust. In recognition of his services the stockholders gave him a gold vase, now on exhibition in the Metropolitan Museum of Art, of which institution he was a trustee.

Meanwhile he retired from Winslow, Lanier & Company to represent in America the Deutsche Bank of Berlin, in which rôle he continued till the outbreak of the World War in 1914. In 1896, when the financial depression of the nineties was at its worst, he acted as the bank's representative in purchasing $200,000,000 of United States 4 per cent gold bonds, in which transaction full discretionary powers were given him. He arranged this in such a way that the Government was protected from withdrawal of gold and its credit strengthened.

He also was affiliated with the Edison Electric Light Company. Becoming interested in the possibilities of developing electric power at Niagara Falls, he organized a group of scientists known as the International Niagara Commission, headed by the British scientist, Lord Kelvin. It met in London and endorsed Mr. Adams' idea of a great central station for distribution of power, but opposed his proposal to employ alternating current, now used universally in transmission systems of this type.

George Westinghouse manufactured generators of the type sought by the financier. The Niagara project was completed in 1895 by the Cataract Construction Company, which Mr. Adams served as president until 1909. His story of the harnessing of Niagara is recounted in a two-volume history written by him a few years ago.

He also played a part in the reorganization in 1893 of the $300,000,000 Northern Pacific Railroad Company and in the financing of a merger of the Chicago & Northern Pacific Railroad and the Chicago & Calumet Railroad with the Chicago Terminal Transfer Company, of which he was president from 1897 to 1901.

Despite his many financial and engineering activities, Mr. Adams maintained an interest in literature, the sciences, and the arts. Among his gifts to the Metropolitan Museum are Rodin's "Hand of God," Lewin-Funke's "Mutter," and Rudolf Marschall's "Good Shepherd." In 1911 he established at Columbia University the Deutsches Haus, the first of the foreign houses for the promotion of international understanding to be founded there. For the last 21 years he served as chairman of the board of the Kahn Foundation for the Foreign Travel of American Teachers.

During the World War Mr. Adams was a director of the American Committee for Devastated France, to which he made

contributions. After the war, he presided at a meeting at which Marshal Foch, then visiting the United States, was made an honorary member of four engineering societies.

Mr. Adams was invested with the following honors: Royal Order of the Crown of Prussia, Second Class, 1909; Médaille de Reconnaissance (with silver star) of the French Republic, 1921; John Fritz Gold Medal, 1926; Commander of the Order of the Crown (of Leopold) of Belgium, 1928; Chévalier de l'ordre National de la Légion d'honneur, 1929. His alma mater, Norwich University, honored him with the degrees of M.S. in 1897, LL.D. in 1906, M.A. in 1908, and Sc.D. in 1927. The honorary degree of Doctor of Science was conferred upon him in 1928 by Louvain University, and in 1930 by Columbia.

He had been a trustee, fellow, patron, or life member of the following organizations: American Academy in Rome, American Institute of Electrical Engineers, American Scenic and Historic Preservation Society, Friends of the Library of Columbia University, National Research Council, New York Geneaological and Biographical Society, New York Botanical Garden, United Engineering Trustees, Inc., and World Congress of Engineering in Japan.

He was an active member of many scientific, engineering, and patriotic societies. Among them are the following: American Association for the Advancement of Science, American Association of Museums, American Electrochemical Society, American Society of the French Legion of Honor, American Federation of Arts, American Forestry Association, American Hellenic Society, American Museum of Natural History, American Red Cross, Legal Aid Society, National Academy of Design, National Society of Mural Painters, New England Society, New York Academy of Sciences, Pan-American Society of the United States, Society of Friends of Rumania, Society for the Preservation of New England Antiquities, and Society of Sons of the Revolution. He was on the advisory board of the school of business of Columbia University.

He belonged to the following clubs: Adirondack League, Automobile, Bankers of American, Church Club of New York, City Club of New York, Engineers, Faculty Club of Columbia University, Grolier, Metropolitan, Recess, Norwich, Riding, Rumson Country, Sea Bright Beach, Sea Bright Lawn Tennis and Cricket, Technology, Tuxedo, and Union League.

Among the companies and corporations which Mr. Adams served at various times as president, vice-president, or director are the following: Bullock Electric Manufacturing Company, East Jersey Water Company, N. K. Fairbanks Company, Lehigh Coke Company, Rumson Improvement Company, Central and South America Telegraph Company, St. Paul & Northern Pacific Railroad, All American Cables, Inc., Allis-Chalmers Bullock, Ltd., Allis-Chalmers Company, American Cotton Oil Company, Bullock Electric Manufacturing Company, Carolina, Clinchfield & Ohio Railway Company, Cataract Power and Conduit Company, Davis Coal and Coke Company, Denver & Rio Grande Railroad Company, Elkhorn Corporation, Hammond Typewriter Company, Intertype Corporation, Missouri Pacific Railway Company, Mohawk Hydro-Electric Company, Niagara Development Company, Niagara Junction Railway Company, Northern Pacific Railway Co., St. Louis, Iron Mountain & Southern Railway Company, Union Petroleum Company, West Shore Railroad Company, and the Missouri Pacific Railroad Company.

In 1872 Mr. Adams married Frances Amelia Gutterson, of Boston. She died in 1921.

Book Reviews and Library Notes

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E. It is administered by the United Engineering Trustees, Inc., as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

William LeRoy Emmet

AUTOBIOGRAPHY OF AN ENGINEER. By William LeRoy Emmet, with an Introduction by E. W. Rice, Jr. Fort Orange Press, Albany, N. Y., 1931. Cloth, 5½ × 8¼, 213 pp., illus., $2.

REVIEWED BY GEO. A. ORROK[1]

WHEN a man has completed the three score and ten years allowed him by the Psalmist, if he can look back over his lifetime of work and point to one constructive accomplishment he may consider that his life has been a success; but when he can point to a noted success in four rather distinct lines of activity which have greatly contributed to the phenomenal position attained by this country in the use of power, an account of the development of these ideas into practical demonstration in his own words is indeed valuable.

William LeRoy Emmet was graduated at the Naval Academy in 1881, and entered the electrical field at the beginning of the industry. He participated in the trials and tribulations of the early street-railway systems, helping in the solution of many problems. With the Edison General Electric Company he became engineer of the power and light department, being largely responsible for the numerous improvements in switchgear, generators, and the application of transformers and rotary converters. Later he created the turbine department of the General Electric Company, being responsible for a great deal of

[1] Consulting Engineer, New York, N. Y. Mem. A.S.M.E.

the developments of the Curtiss turbine and of the modern large-size units. The final scene of his activities lies in the development of the mercury turbine and boiler, which might be considered as the crowning exploit of a well-spent life. He has told the story of his life as a running commentary, giving maximum credit to his collaborators and friends.

Biographical sketches and biographies are always colored to a greater or less extent by the personal knowledge and tastes of the biographer. The point of view is objective: he sees the successes or failures, but he cannot know the personal point of view of the man himself. The genesis of the new ideas, the personal equation, the influence of friends and of environment, are all lost in the attempt to portray the fact apart from the inner urge and the spiritual and intellectual influences. If the subject is articulate, his notebooks, private letters, and his personal conversation may help the biographer to an imperfect picture of the man and his attainments. But the better half of the picture is lost with the internal workings and worries, the seekings after light, the many cognate lines of thought and interest which an autobiography may bring out for the clarification of history and the enlightenment and guidance of the coming generations of engineers. It is to be hoped that many other engineers may emulate the example of William LeRoy Emmet with the same earnestness of purpose, modesty of expression, and innate sense of the values of both work and personality.

Preventive Management

PREVENTIVE MANAGEMENT: Mental Hygiene in Industry. Edited by Henry B. Elkind, M.D. B. C. Forbes Publishing Co., 1931. Cloth, 5¼ × 8 in., 234 pp., 3 figs., $3.

REVIEWED BY JOHN R. BANGS, JR.[2]

PREVENTIVE MANAGEMENT is a significant contribution to modern business and industry. It deals with the highly significant field of human relations in true preventive style. The authors, all of them foremost authorities in their respective fields, present in clear and stimulating fashion the many aspects of this complex problem.

Its contents comprise twelve chapters, contributed by as many authors, with a foreword by Henry P. Kendall, President, The Kendall Co. of Boston, Mass.

Preventive management, as Meyer Bloomfield points out in the opening chapter, is the next step in industrial relations. In speaking of an organization, he raises the highly important question, "Is its mental condition good?" Further, he points out that a sound human balance sheet may be just as important as a sound financial balance sheet to the owner and the manager. It is the guarantee of preventive management, and the executive, ever an operator in the field of human behavior, should take full cognizance of this fundamental truth.

Ordway Tead, in discussing "Human Nature and Management," stresses the need for a more up-to-date psychology—a psychology of the total situation, a psychology of the behavior of the individual as a whole.

Mr. Tead blazes new trails for modern management. He presents in invigorating fashion the psychological problem of company objectives, and of company leadership, emphasizing that the challenge of today is to get leaders of vision, who will see that industrial life becomes creative for all associated with it.

"Psychiatry in Industry," as described by V. V. Anderson, M.D., is mainly a technique in personnel work. Psychiatry finds its real setting in industrial-relations work, where its technique can be made to serve most effectively as an operating, rather than as a consulting, function.

[2] Professor of Industrial Engineering and Director of Personnel, College of Engineering, Cornell University, Ithaca, N. Y.

Dr. Anderson's studies show that approximately 20 per cent of the employees of mercantile establishments are so-called "problem" individuals, whose difficulties arise from maladjusted personalities, specialized job disabilities, and faulty physical conditions. He emphasizes the individual method in the treatment of such problem individuals, and therein psychiatry offers valuable aid to management.

As Henry B. Elkind, M.D., remarks in his chapter dealing with practical applications of mental hygiene in industry, "We are not trying to ask industry to apply strange principles but we are only asking that they put into practice scientific principles that are accepted almost everywhere in the world today."

The scientific approach, so marked in other fields of management, has not had its counterpart on the human-relations side. The sciences of psychology, psychiatry, physiology, and sociology have not proved very popular in scientific management, for the simple reason that the yardsticks by which their results are gaged are, as yet, quite intangible. To ignore such sciences only because their variables are difficult to measure is an illogical procedure, to say the least. A truly scientific system of management should consider all fields of science known to man today, and make the best practical use of them.

Ability to lead is ability to get people to act mentally and physically. Yet the pathway of true leadership is beset with many pitfalls which Dr. Harlow S. Person describes in no uncertain terms. The executive should clearly perceive that he is a leader, that he understands the scope of his responsibilities and the major factors involved, and that he constantly defines and redefines the objectives of his organization. Dr. Person's evolution of a good-will theory of employer-employee relations which he coordinates with his principles of leadership is a real contribution to modern management.

The problems of fatigue and morbid emotions have many practical managerial aspects, as Karl M. Bowman, M.D., aptly points out. Morbid fear, worry, depression, and fatigue lower a worker's efficiency. Truly there is nothing more fatiguing than an unpleasant emotion.

We find what seems to be a constitutional tendency in a great many persons to "ups and downs." Psychologically these are disturbances in mood or activity level leading to periods of elation and depression. Such persons require careful handling, and usually are poor employment risks.

Fear and nervous energy play an important part in employee health and efficiency, and, as Abraham Myerson, M.D., states in his chapter on that subject, "the mental and physical life of man are linked together in an endless circle." Normal and abnormal fears are discussed in their true light. Normal fear is a conservative force holding mankind together. Abnormal fears are contagious, spreading from person to person, tending to disrupt any consolidated group.

Dr. Myerson discusses a source of abnormal fear that arises from overemphasis on achievement and consequent senseless striving. All persons have a certain achievement level, determined by their basic mental and physical qualities, and excessive striving beyond such levels will, sooner or later, result in fears and obsessions that may bring ruin in their wake.

The work is brought to a close by a timely chapter on "The Minor Executive and Mental Hygiene," by Prof. Elliott Dunlop Smith. It not only brings mental hygiene down to practical terms, but applies it to the men or women who are the principal practitioners in industry.

Professor Smith rightfully insists that the junior executive, is the one best qualified to adapt the individual to the environment and the environment to the individual.

Because of its fresh insight into the most advanced methods in human relations, the book should prove valuable to executives in

all fields, to men and women in supervisory positions, and to all others who, in the course of their duties, find it necessary to direct the efforts of their fellows. It is a timely presentation of a subject to which representative men in industry are giving serious thought, and to such men the advice contained in it will be found to be extremely practical.

Personally, the reviewer has believed for some time that a definite professional training in the humanistic sciences is imperative for the modern executive and his understudies. May we not then, in the near future, have a well-planned course of such training for employment interviewers, for personnel directors, and for major and minor executives?

Books Received in the Library

CHEMICAL TECHNOLOGY OF STEAM-RAISING PLANT. By H. N. Bassett. Longmans, Green & Co., London and New York, 1931. Cloth, 6 × 9 in., 240 pp., diagrams, charts, tables, $5.

A discussion of the chemical phenomena of the boiler-plant, written by a chemist for the information of the boiler-house engineer. Water supplies and their treatment, scale removers and boiler compounds, corrosion and its prevention, fuels and their properties, insulating materials, and similar subjects are discussed.

UEBER DIE DAUERBIEGEFESTIGKEIT EINIGER EISENWERKSTOFFE UND IHRE BEEINFLUSSUNG DURCH TEMPERATUR UND KERBWIRKUNG. By E. Kaufmann. J. Springer, Berlin, 1931. Paper, 6 × 9 in., 89 pp., illus., diagrams, charts, tables, 9 r.m.

A report of tests on carbon and chromium-nickel steels and cast iron, to determine their fatigue-resisting properties and the variation of these properties with changes in temperature. A bibliography is included.

DIE HEIZUNG VON SCHULGEBÄUDEN. (Beihefte zum Gesundheits-Ingenieur, Reihe 1, Heft 29.) By C. Eberle and W. Raiss. R. Oldenbourg, Munich and Berlin, 1931. Paper, 9 × 13 in., 24 pp., charts, diagrams, tables, 4.50 r.m.

In order to obtain accurate information concerning the heating necessary for school buildings and the comparative efficiency of steam, hot water and stoves, tests were made in a number of German schools. The results and conclusions are presented in this report.

ELASTIC ENERGY THEORY. By J. A. Van Den Broek. John Wiley & Sons, New York, 1931. Cloth, 6 × 9 in., 260 pp., diagrams, tables, $4.50.

The theory of elastic energy is commonly neglected by American writers on the strength of materials, says the author of the present work, and comes to the student piecemeal, through books on design, with some confusion of terminology. The present work aims to eliminate this difficulty by presenting the theory systematically. The basic philosophy is here deduced directly from the principles of the conservation of energy and applied to a wide range of problems in structural design.

FLOW AND MEASUREMENT OF AIR AND GASES. By A. B. Eason. Charles Griffin & Co., Ltd., London, 1930. Cloth, 6 × 9 in., 254 pp., diagrams, charts, tables, 20s.

Treats of the friction of gases and the coefficient of friction in pipes, the question of suitable meters for gas and air, and the working of pneumatic tubes. The existing information is very fully summarized and presented in tables and graphs, with complete references to sources.

GRUNDZÜGE DER TECHNISCHEN SCHWINGUNGSLEHRE. By O. Föppl. J. Springer, Berlin, 1931. Cloth, 5 × 8 in., 212 pp., illus., diagrams, tables, 9.50 r.m. Second edition.

A concise treatise on the theory of vibration and its applications in engineering. The effects of vibration upon structural materials, methods of calculating frequencies, damping devices, the prevention of vibration in reciprocating machines, and similar topics are discussed.

HANDBUCH DER ZIEHTECHNIK. By W. Sellin. J. Springer, Berlin, 1931. Cloth, 6 × 9 in., 360 pp., illus., diagrams, tables, charts, 32 r.m.

A thoroughly practical treatise on the press working of sheet metal. The materials, machines, and tools are discussed in detail, and the selection of processes and the design of dies, punches, etc., are treated at length.

HIGH-SPEED DIESEL ENGINES. By A. H. Goldingham. E. & F. Spon, Ltd., London, 1931. Cloth, 6 × 9 in., 148 pp., illus., diagrams, charts, tables, 10s. 6d.

After an introductory chapter upon the theory and advantages of this engine, the various systems of fuel injection are described in detail. The remaining two-thirds of the book describes various types of high-speed Diesel engines. The book summarizes the present position of this engine in convenient form.

"HÜTTE" DES INGENIEURS TASCHENBUCH. 26 Auflage, 1 Band, 1931. By Akademische Verein Hütte. W. Ernst u. Sohn, Berlin, 1931. Cloth, 5 × 8 in., 1199 pp., diagrams, charts, tables, 17.50 r.m.; leather, 20.50 r.m.

The first volume of the new edition covers such fundamental matters as mathematics, mechanics, technical physics, heat, strength of materials, materials, measurements, and surveying. Compared with the previous edition, this is ten per cent larger and has been thoroughly revised throughout. Hütte still remains the most comprehensive collection of engineering tables, formulas, and general information in print.

KONTROLLEN DER BETRIEBSWIRTSCHAFT. (Schriften der Arbeitsgemeinschaft Deutscher Betriebsingenieure, Bd. 8.) By O. Kienzle. J. Springer, Berlin, 1931. Cloth, 6 × 9 in., 379 pp., illus., diagrams, charts, tables, 26.50 r.m.

A series of lectures upon various phases of control in manufacturing plants, delivered to a group of management engineers in Berlin during 1929 and 1930. The economic limits of control, methods of controlling quality, quantity, and time in manufacturing operations, the control of power consumption, materials and stores control, and similar topics are treated.

KREISELRÄDER ALS PUMPEN UND TURBINEN. v. 1. Grundlagen u. Grundzüge. By W. Spannhake. J. Springer, Berlin, 1931. Cloth, 6 × 10 in., 320 pp., illus., diagrams, tables, 29 r.m.

A textbook on hydraulic turbines and centrifugal pumps which presents the general hydrodynamic principles of fluid flow, develops the basic theory of these machines, and discusses its application to turbines for various puroses and conditions. A special section is devoted to the Pelton wheel. The book aims to give the student a thorough understanding of the basic theory of turbine design. Succeeding volumes will discuss the application of the theory and the construction of turbines.

LIST OF ALLOYS, WITH PHYSICAL PROPERTIES OF TYPICAL ALLOYS. By W. Campbell. American Society for Testing Materials, Philadelphia, 1930. Paper, 6 × 9 in., 65 pp., $1.50; cloth, $2.

Over 2500 alloys are represented. These are mostly nonferrous alloys, but certain non-corrosive and heat-resistant iron alloys are included. The composition of each alloy is given and, in some cases, the physical properties.

LUMBER AND ITS USES. By R. S. Kellogg. Scientific Book Corporation, New York, 1931. Cloth, 6 × 9 in., 378 pp., illus., diagram, charts, maps, tables, $4.

The information usually wanted by manufacturers, dealers,

and users of lumber as presented in succinct, practical form.

MATHEMATICAL TABLES AND FORMULAS. By R. D. Carmichael and E. R. Smith. Ginn & Co., Boston and New York, 1931. Cloth, 6 × 9 in., 269 pp., diagrams, tables, $2.

This compilation aims to meet the needs of students in mathematics courses and other courses that require mathematical computations or involve mathematical processes. It contains the usual logarithmic and trigonometric tables, up to five places, needed in the study of college algebra and trigonometry; other numerical tables frequently used in computation; and a collection of mathematical formulas, integrals, and series.

MECHANICAL PROPERTIES OF WOOD. By G. A. Garratt. John Wiley & Sons, New York, 1931. Cloth, 6 × 9 in., 276 pp., illus., diagrams, tables, charts, $3.50.

Intended primarily as a text for students of forest utilization and wood technology, but also generally as a concise account of the technical properties of wood. The scope of the book is indicated by the title. Many tables are included, showing the strengths of the more important American woods; grading rules are given, and lists of references are appended to the chapters.

MODERN DIESEL-ENGINE PRACTICE. By O. Adams. Norman W. Henley Publishing Co., New York, 1931. Cloth, 6 × 10 in., 656 pp., illus., diagrams, tables, $6.

A descriptive work, intended primarily for the operating engineer and the owner. Special attention is given to applications of Diesel engines, and to operating and maintenance practice. Aircraft engines and locomotives are included.

NON-INTERPOLATING LOGARITHMS, COLOGARITHMS, AND ANTILOGARITHMS. By Frederick W. Johnson. Simplified Series Publishing Co., San Francisco, 1930. 6 × 9 in., 23 pp., tables, limp cloth, note-book edit., $1.60; fabrikoid, $2.25; full leather, $4.

Four-place and five-place logarithms and antilogarithms, and four-place cologarithms can be obtained from these tables by inspection, without any calculation. The tables are very compactly printed, in clear type, on substantial paper, and are thumb indexed. Additional tables of constants, metric conversion factors, and other frequently used data are included.

NATURAL TRIGONOMETRIC FUNCTIONS to Seven Decimal Places for Every Ten Seconds of Arc, Together With Miscellaneous Tables. By H. C. Ives. John Wiley & Sons, New York, 1931. Cloth, 7 × 10 in., 329 pp., diagrams, charts, tables, $2.50.

The miscellaneous tables include lengths of arc of radius unity, coefficient K for certain angles of certain curves, radii from arc definition and chord definition, curves with even-foot radii, corrections to tangent and external distances, and other data frequently wanted. The tables are clear and the book is convenient.

PERSONNEL PROBLEMS. Methods of Analysis and Control. By F. E. Baridon and E. H. Loomis. McGraw-Hill Book Co., New York, 1931. Cloth, 6 × 9 in., 452 pp., diagrams, charts, tables, $5.

Intended as guide in the study and solution of these problems. The questions that constantly arise under modern industrial conditions are outlined specifically, and methods for their analysis and control are suggested.

PREPARING FOR AVIATION. By V. C. Finch. Simmons-Boardman Publishing Co., New York, 1931. Cloth, 6 × 9 in., 458 pp., illus., diagrams, tables, $4.

A simple presentation of the fundamentals of airplane construction and operation, intended for students of aviation and designed to stand between primary texts and theoretical treatises. The design and construction of airplanes, and the design, construction, and maintenance of airplane engines are discussed. Special chapters are devoted to seaplanes, gliders, the autogiro, instruments, and parachutes. Airports and piloting are also treated.

QUANTITY AND ECONOMY IN MANUFACTURE. By F. E. Raymond. McGraw-Hill Book Co., New York, 1931. Cloth, 6 × 9 in., 375 pp., illus., diagrams, charts, tables, $4.

A discussion of economic production quantities, for business executives. The author gives methods for determining economic lot sizes which have been proved in practice. The latter part of the book discusses the theory of economical manufacture, and analyzes the factors and their relationships.

REDUCING SEASONAL UNEMPLOYMENT. By E. S. Smith. McGraw-Hill Book Co., New York, 1931. Cloth, 6 × 9 in., 296 pp., charts, tables, 9 × 6 in., $3.

The report of an investigation of seasonal slumps sponsored by a group of prominent business men. The experiences of several hundred experienced manufacturers are related. Methods of leveling seasonal fluctuations in sales, production, and employment in a wide variety of industries are described.

S.A.E. HANDBOOK. 1931 edition. Society of Automotive Engineers, N. Y. Cloth, 4 × 8 in., 752 pp., diagrams, charts, tables, $5 to non-members.

Contains the standards and recommended practice of the Society, revised to March, 1931.

SCHWINGUNGEN IN AUTOMOBILLENKUNGEN ("Shimmy"). Bericht der Versuchsanstalt für Kraftfahrzeuge und des Festigkeitslaboratoriums der Technischen Hochschule zu Berlin. By G. Becker, H. Fromm, and Maruhn. M. Krayn, Berlin, 1931. Cloth, 8 × 11 in., 150 pp., illus., diagrams, charts, tables, 15 r.m.

The dangerous vibration of automobile steering systems, known as "shimmy," which has accompanied the introduction of low-pressure tires, has been investigated analytically and experimentally at the Berlin Technical High School. The different factors that affect this form of vibration have been investigated, and methods for preventing or neutralizing it are discussed.

SPEISEWASSER UND SPEISEWASSERPFLEGE IM NEUZEITLICHEN DAMPFBETRIEB. By R. Stumper. J. Springer, Berlin, 1931. Paper, 6 × 9 in., 171 pp., illus., diagrams, charts, tables, 9.60 r.m.

A concise, practical discussion of the problem of feedwater for modern boilers. The author shows the effects of various impurities upon the structure of the boiler and upon boiler operation, gives specifications for suitable feedwaters, and describes current methods of purification and treatment.

TREATISE ON LEATHER BELTING. By G. B. Haven and G. W. Swett. Technical Composition Co., Cambridge, Mass., 1931. Cloth, 5 × 8 in., 249 pp., illus., diagrams, charts, tables, $1.50.

A practical handbook on the manufacture, use, and care of belts, for engineers and others interested in the installation and use of power-transmission belting. The work summarizes very effectively the principal information upon this subject.

UNIFLOW, BACK-PRESSURE AND STEAM EXTRACTION ENGINES. By Lieut.-Com. T. Allen. Isaac Pitman & Sons, London and New York, 1931. Cloth, 6 × 9 in., 660 pp., illus., diagrams, charts, tables, $10.

A systematic treatise upon the design and use of these types of reciprocating engines. The basic tables of mean effective pressure, steam consumption, and mechanical characteristics needed by designers are given, and the method of applying them is given. The designs developed by various manufacturers are described, and such matters as governing, erecting, and testing are treated.

Synopses of A.S.M.E. Transactions Papers

MANAGEMENT PAPERS

AMERICAN MANAGEMENT IN EUROPE. By Wallace Clark. [Paper No. MAN-53-1]

The growing interest of European industrialists in American methods of management is well known. For a long time they believed that the purchase of the most efficient machines and equipment would bring them American prosperity, but they have learned, as has been learned in the United States, that management is quite as important as machines and processes. For the past four years the author and his organization have been engaged in installing management methods in a wide variety of mines and other industrial plants in nine European countries, and in this paper he outlines some of the characteristics of European industry which he noted in the course of his work, and indicates how these methods have been adapted to foreign conditions.

APPRENTICE TRAINING IN VIRGINIA. By C. F. Bailey. [Paper No. MAN-53-2a]

Virginia, along with the rest of the South, is becoming industrially minded. This stresses the need for education for the industries and the arts. The transportation companies, iron works, and shipbuilding concerns require skilled mechanics, trained through apprenticeship. The primary principles in apprentice training are, first, careful selection of candidates; second, importance of the supervisor; and, third, the sympathy and aid of the management. The advantages of apprentice training include recruiting skilled mechanics, with a spirit of loyalty and service, some of whom will develop to foremen and higher officials. To promote this, training schools, on company's time, are advisable. The apprentice group should be self-governing. The conclusions are that the wages should be liberal, with opportunity for increased earnings through premium or bonus work. The prospects for apprentice-trained men were never so bright as now. Virginia manufacturers are taking increased interest, and they recognize the necessity and value of apprentice training. The business of building involves both material and personnel—the building of men as well as of machines and ships.

APPRENTICE TRAINING MOVEMENT IN WISCONSIN INDUSTRY. By Harold S. Falk. [Paper No. MAN-53-2b]

The apprenticeship movement in Wisconsin has been made a concerted organized effort. In developing the work important considerations and tendencies have been taken into account, such as the shortage of skilled mechanics in American industries at the present time in spite of considerable unemployment, the requirements of production as well as of jobbing industries for trained men, and the importance of the human factor in all industry. Employers and employees have cooperated in the promotion and support of an apprenticeship law in the state which stabilizes and dignifies apprenticeship by preventing exploitation of boys and by setting standards of workmanship in the trades. As a result of public favor and the enthusiasm of influential individuals, apprentice training has developed rapidly in the state. There are 3350 apprentices employed, and 2567 have graduated in the last 15 years. At the present rate of graduation, this number will be increased very much in the next 15 years.

A GENERATION OF PROGRESS IN HUMAN ENGINEERING. By William A. Hanley. [Paper No. MAN-53-3]

In this paper the author has considered two manufacturing plants of about the same size, and in the same state, and contrasted conditions under which labor worked in these factories 30 years ago and conditions as they are today. The subjects covered deal with nearly every phase of factory employment. Some interesting conclusions are drawn.

WOOD INDUSTRIES PAPERS

DESIGN OF FURNACES AND FUEL FEEDERS FOR BURNING REFUSE. By M. A. Hofft. [Paper No. WDI-53-1]

This paper includes a discussion of (1) a recent development in the design of a furnace for burning dry wood refuse in suspension; (2) factors influencing the design of wood-burning furnaces in industrial plants; (3) the development of inclined-grate furnaces for burning refuse fuels; and (4) the development of automatically controlled dry-wood-refuse feeders and storage bins.

LONGITUDINAL SHRINKAGE OF WOOD. By Arthur Koehler. [Paper No. WDI-53-2]

Longitudinal shrinkage of wood ordinarily is so small as to be considered negligible, and no allowance is made for it for most uses. There are uses, however, for which even the small longitudinal shrinkage of normal wood is an important factor, and others in which the shrinkage along the grain of abnormal wood is so large as to be a serious handicap. This paper gives information on the shrinkage of wood along the grain, about which very little has been published.

CURVED AND BENT PLYWOOD. By Thomas D. Perry. [Paper No. WDI-53-3]

Curved surfaces on solid wood reveal unattractive wood grain and are seriously lacking in strength and rigidity. The veneering of curved surfaces on solid wood is an ancient art. A description of the curving of plywood for modern designs is timely, since curved surfaces are passing through a period of style popularity. The paper gives a concise description of the building of curved plywood, as well as of the bending of plywood by processes just emerging from the experimental stage. Suggestions are given for the necessary tolerances in size and shape, the trimming and sanding of the curved shapes, and the accessory equipment required therefor. Attention is called to the fact that, pound for pound, wood is the strongest material known; hence curved plywood has an opportunity to become an industrial product with wide applications and substantial economic value.

STANDARDS AND TESTS FOR COATED ABRASIVES. By E. C. Schacht. [Paper No. WDI-53-4]

The paper presents some of the standardization measures which have been undertaken by the sandpaper industry, tracing their evolution and influence on the product. Typical factory-control methods used in the manufacture of coated abrasives are described, together with testing media for evaluating the cutting efficiency of the finished product.

NOTE: Those who have not registered in the A.S.M.E. Management and Wood Industries Divisions, whose papers are abstracted on this page, and who desire copies of any of these papers, may obtain them by using the form given below.

TO THE SECRETARY, A.S.M.E., 29 West 39th Street, New York, N. Y. Date.....

Please send copies of paper checked below:

Management [MAN-53-1] [MAN-53-2a] [MAN-53-2b] [MAN-53-3]

Wood Industries [WDI-53-1] [WDI-53-2] [WDI-53-3] [WDI-53-4]

PRINT name (Important) .....

Street Address..... City.....

Current Mechanical Engineering Literature

Selected References From The Engineering Index Service

(The Engineering Index Service Is Registered in the United States, Great Britain, and Canada by the A.S.M.E.)

THE ENGINEERING INDEX SERVICE furnishes to its subscribers a Weekly Card Index of references to the periodical literature of the world covering every phase of engineering activity, including Aeronautic, Chemical, Civil, Electrical, Management, Mechanical, Mining and Metallurgical, Naval and Marine, Railway, etc. Of the many items of particular interest to mechanical engineers a few are selected for presentation each month in this section of "Mechanical Engineering." In operating The Engineering Index Service, The American Society of Mechanical Engineers makes available the information contained in the more than 1800 technical publications received by the Engineering Societies Library (New York), thus bringing the great resources of that library to the entire engineering profession. At the end of the year all references issued by the Service are published in book form, this annual volume being known as The Engineering Index.

Photoprint copies (white printing on a black background) of any of the articles listed in the Index may be obtained at a price of 25 cents a page. When ordering photoprints identify the article by quoting from the index item: (1) Title of article; (2) Name of periodical in which it appeared; (3) Volume, number, and date of publication; (4) Page numbers. A remittance of 25 cents a page should accompany the order. Orders should be sent to the Engineering Societies Library, 29 West 39th Street, New York.

AIR COMPRESSORS

High-Pressure. Das Waermeproblem bei Hochdruckkompressoren (Heat Problem in High-Pressure Compressors), W. Hotzel. Zeit. fuer Komprimierte und Fluessige Gase, vol. 29, no. 1, 1931, pp. 1–3. Formulas, air gravity, air preheating, mean temperature and specific volume, heat discharge and air coolers for low-pressure stage; air coolers and determination of pipe coils for high-pressure stage.

Rotary. Improvements in Rotary-Compressor Design. Iron and Coal Trades Rev., vol. 122, no. 3285, Feb. 13, 1931, p. 279, 2 figs. Notes on Hick Hargreaves machine, of crescent type, arranged with system of restraining rings, which control and restrict pressure of blades in casing; arrangement enables machine to be run at high speed, and renders it suitable for direct coupling to most types of prime movers; machine built in sizes with suction capacities 10 to 6000 cu. ft. free air per min., to be delivered at pressures up to 200 lb. per sq. in. and to vacuum of 95 per cent; two-stage compressors are fitted with intercoolers of tubular type.

AIR PREHEATERS

Installation. Der nachtraegliche Einbau von Luftvorwaermern in vorhandene Kesselanlagen (Installation of Air Preheaters in Existing Boiler Plants), W. Gumz. Feuerungstechnik, vol. 19, no. 4, Apr. 15, 1931, pp. 57–61, 5 figs. Technical and economic reasons for addition of air preheater to existing plant; fuel and temperature conditions; advantages of installation; increase of efficiency.

AIRPLANE ENGINES

Bearings. Bearing Loads on Radial-Engine Crankshafts, E. S. Taylor. Soc. Automotive Engrs.—Jl., vol. 28, no. 4, Apr. 1931, pp. 481–485, 6 figs. Determination of approximate distribution of loads on main bearings of radial aircraft engines, so that bearings can be correctly proportioned and stresses in crankshaft can be more accurately calculated; short method of calculating crankpin-bearing load; graphs and tables illustrate results of static tests of six radial-engine crankshafts for determination of bearing loads.

Crankshafts. Aircraft Engine Crankshafts, E. F. Lake. Heat Treating and Forging, vol. 17, no. 4, Apr. 1931, pp. 352–356 and 359, 4 figs. Physical properties, heat treatment and forging of chromium-nickel steels; graphs illustrate tensile strength and elastic limit at various drawing temperatures; operation of furnaces and hammer with particular regard to reduction of stresses in finished forging.

Supercharging. The Comparative Performance of Superchargers, O. W. Schey. Nat. Advisory Committee Aeronautics—Report no. 384, 1931, 15 pp., 11 figs. Comparison of superchargers on basis of power required to compress air at definite rate, and on basis of net engine power developed at altitudes from 0 to 40,000 ft.; investigation, which was conducted at Langley Memorial Aeronautical Laboratory, included geared centrifugal, turbine-driven centrifugal, Roots, and vane-type superchargers.

AIRPLANES

Light Alloys for. Leforgeage et le matricage des alliages légers et ultra-légers (Forging and Stamping of Light Alloys and Ultra-Light Alloys), E. Decherf. Aciers Spéciaux Métaux et Alliages, vol. 6, no. 66, Feb. 1931, pp. 60–68, 24 figs. Drop forging and stamping practice illustrated by practical examples; avoiding stresses and cracks by proper design of dies.

AIRSHIPS

Wreck of "R-101." The Loss of the R 101. Engineering, vol. 131, no. 3404, Apr. 10, 1931, pp. 487–488. Editorial comment based on report of Inquiry; consideration of conditions under which airship was constructed; point of extreme importance arises from alterations made to gas bags, which were of novel design; evidence definitely rules out any question of structural failure; explanation of disaster must be associated with substantial loss of gas; it was wrong to commence such enterprise as airship flight to India without extensive preliminary trials; primary consideration must be reduction of risk of fire by every possible means.

ALLOYS

Anti-Corrosive—Tungum Metal. "Tungum Metal." Metal Industry (Lond.), vol. 38, no. 14, Apr. 3, 1931, p. 365. New anti-corrosive alloy can be made into castings, tubes, sheets and wire, etc.; corrosion-resisting and physical properties; Brinell-test results; composition is not given.

Light. See AIRPLANES, Light Alloys for.

ALUMINUM

Protective Coating—Use as. Metallschutz und Legierungen, etc. (Resistance to High Temperatures of Metal Coatings and Alloys), W. Obst. Feuerfest, vol. 7, no. 3, Mar. 1931, pp. 36–37. Process developed by Krupp in Essen, known in Germany as "Alitieren," for protecting metal products against oxidation at high-temperatures; surface of metal is alloyed with aluminum to depth of several millimeters, after which aluminum in this surface layer is again oxidized to refractory alumina; material penetrates into metal and becomes fully alloyed with it; process can be applied to all kinds of malleable iron and to different non-ferrous metals and alloys.

ALUMINUM ALLOYS

Treatment. Les alliages légers et leur traitement (Light Alloys and Their Treatment), Simmonnet. Revue de l'Industrie Minérale, no. 247, Apr. 1, 1931, pp. 122–128. Account of author's experiences with forging and heat treating light alloys for automobile parts and aircraft engines; influence of different constituents; explanation of phenomena of hardening and aging; casting and forging light alloys; hardening and annealing; welding of treated alloys; corrosion; study of alloys with aluminum base.

AUTOMOBILE ENGINES

Combustion Chambers. Der Whatmough-Zylinderkopf im Vergleich zu den bisher ueblichen (Comparison of Whatmough Cylinder Head with Formerly Conventional Type), J. Pannenborg. Automobiltechnische Zeit., vol. 34, no. 10, Apr. 10, 1931, pp. 226–229, 11 figs. Sketches and graphs illustrate Whatmough's principles of combustion-chamber design; comparison of Ricardo's and Whatmough's results.

Ignition. The automotive Ignition Coil, T. H. Darnell. Nat. Advisory Committee Aeronautics—Report, no. 374, 1931, 28 pp., 29 figs. Measurements on secondary voltage induced in ignition coil of typical construction under variety of operating conditions, show that theoretical predictions hitherto made as to behavior of this type of apparatus are in satisfactory agreement with observed facts; experimental results showing effect of secondary capacity and resistance on crest voltage produced by ignition apparatus.

Lubrication. Influence due piston dans la consommation d'huile (Influence of Pistons on Oil Consumption), Dintilhac. Pratique Automobile, vol. 27, nos. 578, 579 and 580, Mar. 1, 1931, pp. 10, 12, and 14; Mar. 15, pp. 18 and 20; and Apr. 1, pp. 20, 22, and 24, 31 figs. Analysis of design problem with particular regard to importance of proper dimensioning of rings and grooves, and location of oil holes to eliminate oil pumping action; graphs illustrate oil consumption of cast-iron and aluminum pistons at speeds from 750 to 6000 r.p.m.

Le graissage des Cylindres par mélange d'huile et d'essence (Lubrication of Cylinders by Mixture of Oil and Gasoline), H. Petit. Société des Ingénieurs de l'Automobile—Jl., vol. 4, no. 2, Feb. 1931, pp. 1267–1274. Critical study of advantages of overhead lubrication with data on heat resistance of special oils and temperature of various parts of engine.

AUTOMOBILES

Bearings. Wirtschaftlicher Einbau von Waelzlagern in Kraftfahrzeuge (Economic Application of Anti-Friction Bearings in Motor Vehicles), Rothweiler. Automobiltechnische Zeit., vol. 34, no. 9, Mar. 31, 1931, pp. 202–204, 5 figs. Study of forces to which various types of bearings are subject with particular regard to application of ball and roller bearings in rear axle; data on bearing life and load.

Brakes. Making Hydraulic Brake Gear. Automobile Engr., vol. 21, no. 279, Apr. 1931, pp. 137–142, 16 figs. Production methods and equip-

ment at works of Lockheed Hydraulic Brake Co., Leamington; data on output and tolerances, speeds and feeds in various machining operations.

Clutches. Étude théorie et pratique des embrayages à disques (Theoretical and Practical Study of Disk Clutches), Dufresne. Société des Ingénieurs de l'Automobile—Jl., vol. 4, no. 1, Jan. 1931, pp. 1218–1332, 13 figs. Fundamentals of dry-disk clutch design with examples illustrating principal calculations involved; critical study of typical French, American, and German practice.

Manufacture—Germany. Das Problem der Produktionskostensenkung in der deutschen kraftahrzeugteile- und Zubehoer-Erzeugung (Problem of Reducing Production Cost in Manufacture of German Motor-Vehicle Parts and Accessories), S. F. Kreitmair. Motor, vol. 19, no. 4, Apr. 1931, pp. 12 and 19–20. Possibilities of improving competitive and manufacturing conditions in German automobile industry together with suggestions concerning mergers, cooperation in establishing standards, and prerequisite of mass production, based on investigations of Bruno Schmidt.

Steel for. Rustless Steels as Applied to Automobiles and Aircraft, W. H. Hatfield. Mech. World, vol. 89, nos. 2308 and 2309, Mar. 27, 1931, pp. 288–289, and Apr. 3, 1931, pp. 322–324, 7 figs. Mar. 27: Table shows empirical compositions of essential rustless steels which have been successfully applied and against each steel is given numbers of specifications which are met by that particular composition; typical mechanical properties representative of different conditions in which steels can be available. Apr. 3: Polishing; soldering and brazing; welding. Before Instn. Automobile Engrs.

Vibrations. Der Puls-Umformer (Puls Converter), E. F. Puls. Automobiltechnische Zeit., vol. 34, no. 10, Apr. 10, 1931, pp. 229–230, 2 figs. Design and operating principles of device for eliminating harmful effect of torsional vibration in transmission system of motor vehicles; device is mounted between transmission and propeller shaft and reduces non-uniformity of impulses originating either in power plant or at rear wheels.

AUTOMOTIVE FUELS

Alcohol. Die Verwendung von Spiritus als Treibstoff in Deutschland (Use of Alcohol and Automotive Motor Fuel in Germany), K. R. Dietrich. Automobiltechnische Zeit., vol. 34, no. 10, Apr. 10, 1931, pp. 234–235. Operating results with alcohol-gasoline mixtures and governmental regulations concerning ratios.

Detonation. Antiknock Fuels and Engine Design, E. Bartholomew and F. Fricker. Oil and Gas Jl., vol. 29, no. 45, Mar. 26, 1931, pp. 38 and 132–133, 7 figs. Automobiles increasing more rapidly than highways; average speed kept up by greater acceleration; present status of airplane; analysis of engine efficiency; advantages of high compression ratio; high compression problem; carbon as problem; lower exhaust temperature; British problem of refineries manufacture of gasoline of sufficiently high antiknock value to meet demand of automotive engines of constantly increasing compressure. Before Am. Chem. Soc.

Research. Fuel Research at Bureau of Standards, O. C. Bridgeman. Oil and Gas Jl., vol. 29, no. 42, Mar. 5, 1931, pp. 143 and 226–227, 1 fig. Scope of investigations; considerable fundamental data of direct concern to refiners already made available; investigations to continue; outline of work on volatility, vapor pressure, gum content, sulphur content, and antiknock value. Bibliography.

B

BALANCING

Machinery. The Balancing of Machinery—XVI and XVII, C. N. Fletcher. Mech. World, vol. 89, nos. 2307 and 2310, Mar. 20, 1931, pp. 275–277, and Apr. 10, pp. 337–340, 9 figs. Mar. 20: Reciprocating masses; Avery connecting-rod balancing machine; Hofmann-Kunze connecting-rod balancing machine; Olsen-Lundgren automatic weighing connecting-rod scale; balancing of locomotives: Kunze-Schmidt balancing machines for complete motorcar, motorboat, or airplane engines. Apr. 10: Practical correction of unbalance; two numerical charts are given.

BLAST FURNACES

Design. Blast-Furnace Problems. Engineering, vol. 131, no. 3405, Apr. 17, 1931, pp. 518–519. Reference to figures published by Blast Furnace and Coke Assn. of Chicago District, considering best proportions for large blast furnace; figures are stated by Association to represent "what we would build if we were board of directors of company, endowed with sufficient capital and location, and wished to enlarge or modernize our pig-iron production capacity to extent of 1000 tons per day;" principal dimensions are: hearth diam., 25 ft. 4 in.; bosh diam., 28 ft. 3 in.; throat diam., 19 ft.; o.a. height, 97 ft. 4 in.

BOILER FURNACES

Pulverized-Coal Burners. Short Flame Powdered Fuel Burner. Eng. and Boiler House Rev., vol. 44, no. 10, Apr. 1931, pp. 658 and 660. 2 figs. Design, construction, and operating characteristics of patent G. P. F. burner which has been installed in powdered fuel fired Lancashire boilers at Careton Main Colliery.

BOILERS

Blowdowns. Continuous Blowing Down of Steam Boilers. Colliery Guardian, vol. 142, no. 3660, Feb. 20, 1931, pp. 664–666, 7 figs. General remarks on practice of blowing down boiler in order to limit concentration of impurities to figure beyond which priming occurs; advantages of continuous blowing down, as compared with intermittent blowdown; continuous blowdown as assistance to water-softening process; effect of concentration of soluble salts in boiler feedwater; ratios of different kinds of soluble salts; features of Boby patent safety continuous blowdown.

Corrosion. The Effect of Boiler Scale on Heat Transmission and Utilisation, A. Pollitt. Instn. Fuel—Jl., vol. 4, no. 16, Apr. 1931, pp. 285–286 and (discussion) 286–297. Heat conductivity coefficients of scales; influence of scale on boiler efficiency; influence of scale on tube-metal temperature.

Design. Stepped Boiler Drums Widely Used in Germany. Power, vol. 73, no. 17, Apr. 28, 1931, p. 662, 2 figs. Design and constructional features of Duerr boiler in which flat areas pressed in drums permits use of straight boiler tubes; among advantages claimed for Garbe and Duerr types of boiler are simplicity, good circulation, reduction of scale deposits in tubes and of ash deposits between tubes.

Water Walls Add 50 Per Cent to Boiler Capacity. Power, vol. 73, no. 16, Apr. 21, 1931, pp. 620–621, 1 fig. Installation of additional water surface on side and rear walls of furnace of boiler plant of Murray Corporation of America, Detroit, Mich.; total surface 1139 sq. ft.; furnace arrangement showing water walls and connections to boiler drums.

Firing Low-Grade Fuels. Beitrag zur Frage der Verheizung geringwertiger und billiger Brennstoffe (Heating with Low-Grade and Cheap Fuels), K. Seiler. Waerme, vol. 54, no. 15, Apr. 11, 1931, pp. 268–274, 9 figs. It is shown that problem of utilizing low-grade fuels has lost none of its importance, but has been extended by recent experiences and knowledge; further means of savings; new forced-draft stoker by Kuester, and results of tests; temperatures in fire grade for number of different coals.

High-Pressure (Loeffler). The Loeffler Boiler From the Boiler-Maker's Point of View, K. Rochel. Engineering, vol. 131, no. 3406, Apr. 24, 1931, pp. 537–540, 11 figs. Invention of Loeffler has produced boiler which gives maximum security in operation at highest pressures and permits control of highest temperatures; consists of superheater, circulating pump and evaporator; construction can be so simple that it is comparable with that of any other boiler, even those for lower pressure; cost is also comparable with that of other boilers. Before World Power Conference, Berlin.

High-Pressure—Insulation of. Das Torkretverfahren beim Bau von Hochdruckkesseln (Torkret Process in Construction of High-Pressure Boilers), F. Binswanger. Waerme, vol. 54, no. 15, Apr. 11, 1931, pp. 277–278. Torkretite E-4 is mixture of grog and raw clay with alumina content of 30 to 35 per cent; when gas temperature is over 1300 deg., more refractory material, E-3, with alumina content of 35 to 39 per cent is used; results of tests at Munich Institute of Technology, at gas temperatures of 800 to 1200 deg., and water temperatures of 250 to 400 deg., on specimens from boiler of Klingenberg power plant after 2 or 3 years of use.

Locomotive. See LOCOMOTIVES, Boilers.

Tubular, Vertical. Die Entwicklung des Steilrohrkessels 1920 bis 1930 (Development of Vertical-Tube Boilers, 1920 to 1930), W. Piepenbrink. Archiv fuer Waermewirtschaft, vol. 12, no. 4, Apr. 1931, pp. 113–116, 10 figs. Stages of development; requirement for calculation and design of vertical-tube boiler; examples of construction in different stages of development; high-capacity boiler with Martin stoker.

Water-Tube—Stresses in. Evaluation des efforts qui prennent naissance dans les plaques à tubes des chaudières aquatubulaires (Evaluation of Stresses Originating in Headers of Watertube Boilers), V. Kammerer and G. Parmentier. Associations Francaises de Proprietaires d'Appareils a Vapeur—Bul., no. 43, Jan. 1931, pp. 1–30, 15 figs. Mathematical investigation of principal stresses including those caused by pressure, irregular shaping, weight, differences in expansion of tubes, temperature effects; stress distribution around and between holes and stresses resulting from rolling in of tubes; elastic limit and safety margin.

Welding. New Technique in Welding Is Result of Years of Scientific Research, K. B. Lydiard. Pit and Quarry, vol. 22, no. 2, Apr. 22, 1931, pp. 62–64, 11 figs. Results of investigations and laboratory experiments by research engineers of Babcock and Wilcox; based on which technique was evolved which produces welds equal to or better than welded plate itself in tensile strength, shock resistance, ductility, and in ability to withstand repeated stresses; results obtained when this technique is used to weld carbon steel of firebox quality.

The Welded Boiler Drums of the U. S. Navy Scout Cruisers, J. C. Hodge. Am. Welding Soc.—Jl., vol. 10, no. 3, Apr. 1931, pp. 11–15, 10 figs. Testing methods in connection with specifications for navy boiler drums, with particular regard to determination of physical and chemical properties of weld metal of joints; X-ray examination of main joints; graphs and tables illustrate test results.

BURNISHING

Machine for. Burnishing With Tungsten Carbide, F. J. Sanders. Machy. (N. Y.), vol. 37, no. 9, May 1931, pp. 674–676, 3 figs. Design of machine in which cams are burnished accurately to size, reducing production costs 80 per cent.

C

CAR RETARDERS

Types. Froelich Hydraulic Car Retarder System at Whitemoor Yard, London and North Eastern Railway (England). Int. Ry. Congress Assn.—Bul., vol. 13, no. 3, Mar. 1931, pp. 226, 8 figs. Design and operating characteristics of system, which is first classification yard in Great Britain to be equipped with Froelich system of hydraulic car retarders, involving semi-automatic switch control; freight traffic facilitated; improved results; wheel and tire difficulty: mechanical and electrical apparatus.

The Erie Installs Retarders in Marion Yard. Ry. Age, vol. 90, no. 15, Apr. 11, 1931, pp. 706–707, 3 figs.; see also Ry. Signaling, vol. 24, no. 4, Apr. 1931, pp. 115–117, 6 figs. Capacity of yard increased and operating cost reduced operating problems; plan of yard layout showing grades; improvements in yard operation.

The Westinghouse Eddy-Current Rail Brake. Engineering, vol. 131, no. 3405, Apr. 17, 1931, p. 530, 2 figs. Particulars of retarder and principle upon which it works; it is claimed that this type of retarder possess number of advantages, both from constructional and operating points of view, over those which depend on mechanical friction for their operation.

CARBON DIOXIDE

Generators. Generator for Production of Carbon Dioxide of High Furity, E. J. Poth. Indus. and Eng. Chem.—Analytical Edition, vol. 3, no. 2, Apr. 15, 1931, pp. 202–203, 1 fig. Although apparatus described has been employed in Texas Laboratory solely for generation of carbon dioxide in connection with estimation of nitrogen by combustion method, principle of construction can be adapted to production of many other gases; generator is compact and is constructed entirely of glass without ground-glass connections; it can be warmed and pumped free of occluded gases; it utilizes its reactants completely without wasting any of gas produced.

Machinery to Make Solid Carbon Dioxide, T. Mitchell. Indus. and Eng. Chem., vol. 23, no. 5, May 1931, pp. 523–525, 5 figs. Plant making solid carbon dioxide comprises three-stage compression system, carbon-dioxide condensers, three-stage liquid coolers, snow chambers, and auxiliaries such as mixers, intercoolers, filters, etc.; several stages of liquid cooling are synchronized with corresponding stages of compression to give better efficiency, reduce size of machinery and save horsepower.

CARS

Dynamometer. Dynamometer Car, South African Railways. Ry. Gaz., vol. 54, no. 14, Apr. 3, 1931, pp. 521–523, 5 figs. Design, construction and operating characteristics of car and equipment; measurement of car speed; ascertaining amount of work performed; elevation and plan used.

Passenger—Riding Qualities. The Riding Qualities of Railway Coaches, P. L. Henderson. Ry. Engr., vol. 52, no. 615, Apr. 1931, pp. 159–166, 14 figs. Review of experiments to determine relative motion of component parts of car trucks; suggested scheme of research work; design and operating features; truck movement recording apparatus; analysis of truck movement charts; time of oscillation of springs; mechanics of trucks.

CASE HARDENING

Carburizing Baths. Behavior of Liquid Carburizing Baths, E. C. Moffett. Iron Age, vol. 127, no. 17, Apr. 23, 1931, pp. 1338–1341, 2 figs. Case hardening by sodium cyanide and mixtures with experimental data covering rate of deterioration of cyanide; calcium cyanide or Aerocase process with method of operating bath and results obtainable. Before Am. Soc. Steel Treating.

CAST IRON

Chromium in. Chromium in Cast-Iron Mixtures, T. F. Jennings. Am. Foundrymen's Assn.—Trans., vol. 2, no. 2, Feb. 1931, pp. 801–809. Use of chromium in cast-iron mixtures as practiced in past and effects produced by varying combinations; Piwowarsky's findings as to effect on hardness, strength, chilling tendency and resistance to abrasion; transverse strength and deflection augmented by additions of chromium up to 0.50 per cent; results of various tests performed by author. Bibliography.

Heat Treatment. Effects on Cast Iron of Prolonged Heating at 800–1100 Deg. Fahr., R. S. MacPherran and R. H. Krueger. Am. Foundrymen's Assn.—Trans., vol. 2, no. 2, Feb. 1931, pp. 826–855 and (discussion) 855–863; also author's closure, pp. 863–864, 16 figs. Various types of cast iron were heated for 500 hr. at temperatures up to 1100 deg. fahr., after which physical and chemical tests were made to determine effect; high silicon materially accelerates decomposition of pearlite, and nickel does same, although to lesser extent; low silicon and low carbon with finely divided graphite flakes tend to delay this action; chromium increases tensile strength at room temperatures and delays decomposition of pearlite.

Some Phases of Heat Treatment of Cylinder and Alloy Irons, F. J. Walls and A. Hartwell, Jr. Am. Foundrymen's Assn.—Trans., vol. 2, no. 3, Mar. 1931, pp. 865–890 and (discussion) 890–896, 16 figs. Relief of stresses and physical changes of cylinder irons by various heat treatments, with particular regard to chromium-molybdenum and chromium-nickel-manganese cast irons; to obtain maximum relief of stresses and minimum of growth and changes in hardness, heat at 950 deg. fahr. and follow by slow cooling; microphotographs illustrate structural characteristics after various heat-treatments.

Machinability. Die Schneidfaehigkeit von Grauguss in Abhaengigkeit vom Silizium- und Kohlenstoffgehalt (Cutting Properties of Gray Cast Iron in Relation to Silicon and Carbon Content), E. Diepschlag and F. Eggert. Giesserei, vol. 18, no. 16, Apr. 17, 1931, pp. 313–318, 13 figs. Investigation of machinability of gray cast iron by measurement of cutting temperature with lathe cutting process; evaluation of results in form of triple-axis diagram of values; carbon content, silicon content and cutting temperature.

CHAINS

Manufacture. The Manufacture of Cycle and Motor Cycle Chains, C. J. Potts. Instn. Production Engrs.—Jl., vol. 9, no. 8, Feb. 1931 pp. 238–242 and (discussion) 242–247. Manufacturing methods and equipment of Coventry Chain Co., Ltd.; chain plates are blanked on presses working at 250 strokes per min.; tolerances, heat treatment and assembling methods.

CONTAINERS

Freight Shipment in. Der Behaelter (Container) Verkehr der deutschen Reichsbahn (Container Transportation of German State Railroads), H. Pressler. Sprechsaal, vol. 64, no. 11, Mar. 12, 1931, pp. 209–212, 3 figs. Use of containers as examplified in shipping department of brick and clay-products manufacturing concern in Germany; large and small containers; system of distribution; problem of economy.

CONVEYORS

Crane. Bucket Excavator With Crane Conveyor, K. Baldauf. Eng. and Min. Jl., vol. 131, no. 8, Apr. 27, 1931, pp. 367–368, 3 figs. Data supplementing article by R. Thomas, previously indexed from issue of Mar. 23, 1931; dimensional details are given and features of excavator equipment outlined; this excavator, designed and built by Maschinenfabrik Buckau R. Wolf A.G., of Magdeburg, was first used in spring of 1929.

Interlocking. The Interlocking of Conveying Systems, A. R. Cooper. Mech. World, vol. 89, no. 2311, Apr. 17, 1931, p. 369, 4 figs. Arrangement of interlocking elevator with its conveyor so that delivery of materials will cease when breakdown of conveyor occurs.

COOLING TOWERS

Design. Influence de la forme et des dimensions sur le fonctionnement et le rendement des réfrigérants d'eau (Influence of Shape and Dimensions on Operation and Efficiency of Water Coolers), V. Nimal. Revue Universelle des Mines, vol. 5, no. 8, Apr. 15, 1931, pp. 213–220, 7 figs. Economy of atmospheric coolers; principles governing design; results of tests on Hamon types of cooling towers, with lateral stepped-grade atmospheric cooling.

COST ACCOUNTING

[See INDUSTRIAL MANAGEMENT.]

CRYSTALS

Strength of. Ueber die Natur der Festigkeit (Strength Characteristics), M. Polyani. Mitteilungen der Deutschen Material pruefungsanstalten, Special No. 13, 1930, pp. 113–119, 15 figs. Nature of strength of deformed crystals rests on connecting line between two limit cases of completely irregular matter; crystalline matter can be plastically deformed, by replacing densest atomic cells parallel to one another.

CUPOLAS

Design. Balanced Blast Cupola, E. Longden. Engineer, vol. 151, no. 3926, Apr. 10, 1931, p. 404, 1 fig. In this cupola it is claimed that gases rich in free air exist for some distance in front of and above tuyere entrance; object of cupola is to promote greater formation of carbon monoxide in melting zone and by gradual addition of further air through upper auxiliary tuyeres to lead to increase in carbon dioxide, and rise in temperature until maximum temperature zone is reached at top of coke bed. Before Manchester Assn. Engrs.

Practice. Aus vorherdlosem Kupolofen hergestelltes Eisen mit niederem Kohlenstoffgehalt (Iron With Low Carbon Content Manufactured in Cupola Without Forehearth), G. Schuele. Zeit. fuer die Gesamte Giessereipraxis, vol. 52, no. 14, Apr. 5, 1931, pp. 108–109. Possibility of melting iron with less than 3 per cent carbon in cupola without forehearth is shown to be entirely feasible.

CYLINDERS

Gaging. The Gauging of Cylinders for Diameter, L. A. Legros. Engineer, vol. 151, no. 3927 Apr. 17, 1931, pp. 436–437, 7 figs. It had been found that among cylindrical products there were some short rollers that measured apparently correct to 0.0001 in. by micrometer, but they were so much "out-of round" that this abnormality could be felt with fingers; this shaking of faith in micrometer as final authority for appeal has suggested matters for investigation discussed in this article.

D

DIESEL ENGINES

Airless-Injection. American Builder Adapts Airless Injection System to Engines of Revised Design. Diesel Power, vol. 9, no. 4, Apr. 1931, pp. 192–194, 8 figs. Busch-Sulzer Bros. Diesel Engine Company reports construction on orders, of several two-cycle, single-action engines incorporating A.E.G.-Hesselman system of mechanical injection and new features of design; trunk pistons with airless injection; design details of engine for Freeport, N. Y.; fuel-injection system.

Automotive. Der Michel-motor, ein neuer Fahrzeugdieselmotor (Michel Engine a New Automotive Diesel Engine), W. Schaar. Automobiltechnische Zeit., vol. 34, no. 11, Apr. 20, 1931, pp. 258–263, 19 figs. Design and operation of 4-cylinder 3-cycle engine; three pistons serve one cylinder, each piston being connected to one of three crank-shafts which are linked by triangular frame; mean effective pressure is 10 kg. per sq. cm., and power output 53 hp. per liter; pressure diagram and rod test data.

Injection and Combustion in High-Speed Diesel Engines Analyzed, S. J. Davies and E. Griffen. Automotive Industries, vol. 64, no. 16, Apr. 18, 1931, pp. 609–613, 9 figs. Effects of elasticity of tube material and compressibility of oil, injection lag and ignition lag; graphs illustrate effect of temperature on bulk moduli of compression of two different gas oils: dependence of rate of heat transfer upon temperature difference between air and fuel particles, with and without turbulence. Before joint meeting of 11 Brit. Eng. Societies.

Untersuchungen an der Dieselmaschine. Der Oberhaensli-Vierzylinder-Rohoelmotor (Diesel-Engine Investigation. Oberhaensli-Four Cylinder-Crude Oil Engine), K. Neumann. V.D.I. Zeit., vol. 75, no. 15, Apr. 11, 1931, pp. 453–455, 6 figs. Design and performance characteristics of engine developing 80 hp. at 1350 r.p.m., with bore and stroke of 130 by 180 mm.; equipped with Bosch fuel-injection system and Bosch glow plug for starting; comparative data on Daimler-Benz, MAN, and Hesselman engines.

Cold Starting. Dual Compression Helps Cold-Starting in Precombustion Chamber Engine. Diesel Engine, vol. 9, no. 4, Apr. 1931, pp. 188–189, 2 figs. Compression of Lister engine raised to 600 lb. per sq. in. during starting period; engine operates on four-stroke cycle and develops 9 b.hp. at 1000 r.p.m. in $4^1/_2 \times 5^1/_2$-in. cylinders; speed of two and four-cylinder units can be raised to 1100 r.p.m., which results in an increase of power up to 11 b.hp. per cylinder; Bosch fuel pumps and injectors are fitted.

Fuel Injection. Coefficients of Discharge of Fuel Injection Nozzles for Compression-Ignition Engines, A. G. Gelalles. Nat. Advisory Committee Aeronautics—Reports, no. 373, 1931, 19 pp., 24 figs. Investigation to determine coefficients of discharge of nozzles with small, round orifices of sizes used with high-speed compression-ignition engines; tests were also made with nozzles assembled in automatic injection valve, both with plain and with helically grooved stem.

L'injection mécanique et les tensions d'origine thermique dans les moteurs à combustion interne (Mechanical Injection and Temperature Stresses in Internal Combustion Engines), P. Maillard. Science et Industrie, vol. 15, no. 206, Mar. 1931, pp. 116–121, 6 figs. Control of thermodynamic efficiency of Diesel cycle by means of proper fuel injection and study of stresses set up in cylinder head and liner with particular reference to experimental work conducted by Sulzer Company, Switzerland, on two-cycle double-acting engine developing 3400 hp. and 120 r.p.m.

The R E F Port-Controlled Fuel-Injection Pump, W. V. Doorer. Motive Power, vol. 2, no. 4, Apr. 1931, pp. 26–28, 6 figs. Requirements for an efficient fuel pump are reliable feeding under highest pressures, ranging from 900 to 1500 lb. per sq. in. in precombustion-chamber and similar systems up to 3500 to 7000 lb. per sq. in. in direct-injection systems, and determination and continuance of time of injection and exact apportionment of fuel harmonizing with different speeds and loads; design, construction, and operating features of R E F fuel pumps; cross-sectional view of R E F pump and fuel-injection nozzle.

Marine. Reducing Lubricating Oil Consumption, O. M. Gordon. Motorship, vol. 16, no. 4, Apr. 1931, pp. 206–208, 2 figs. Special reference to trunk-piston Diesel engines, and importance of using correct grades of oil and proper kind of rings.

The Largest Airless-Injection Engine. Brit. Motor Ship, vol. 7, no. 134, Apr. 1931, p. 35, 2 figs. Double-acting type capable of developing 860 s.hp.; two units completed at Augsburg having highest output of any airless-injection motors yet constructed; for Japanese vessels.

The Present Position of the Diesel Engine for Marine Purposes, H. H. Blache. Engineering, vol. 131, no. 3404, Apr. 10, 1931, pp. 494–497, and discussion 490–491, 4 figs.; see also Engineer, vol. 151, no. 3926, Apr. 10, 1931, pp. 411–412, 5 figs. Position is not yet one of uniform design; procedure in attaching bedplate to double bottom; 4-stroke engine has made progress by introduction of "high-pressure induction," i.e., admitting inlet air under pressure of from 4 to 5 lb. per sq. in.; utilization of heat from exhaust gases; vibration; Diesel engines for warships. Before Inst. Naval Architects.

Pulverized-Fuel. Der Zuend- und Verbrennungsborgang im Kohlenstaubmotor (Combustion Process in Pulverized-Coal Engines), W. Wentzel. Forschungsheft 343, vol. 2, Apr. 1931, 23 pp., 21 figs. Testing device for determination of ignition and combustion rates of pulverized coal, which is blown into compressed heated air by means of compressed air; its application to determination of influence of temperature and density of combustion air, of excess air, blowing pressure, grain size, and nature of coal, on ignition retardation and combustion rate; results are compared with new formula for ignition retardation and with Nusselt Formula for combustion rate.

Scavenging. Recent Trends in Turbo-Scavenging for Diesel Engines, F. J. Taylor, Diesel Power, vol. 9, no. 4, Apr. 1931, pp. 185–187, 5 figs. Recent trends summarized from viewpoint of two-cycle Diesel requirements; comparison with piston pump; blower design; operating characteristics; typical installation.

Testing. Rating and Testing of Diesel Engines, G. F. Swarthout. Motive Power, vol. 2, No. 4, Apr. 1931, pp. 21–23, 11 figs. Indicator-card comparisons; typical indicator cards of Otto cycle and original cycle devised by Dr. Diesel; representative indicator diagrams of modifications of Diesel system used in present-day engines

presenting compression pressure from 500 to 1000 lb. per sq. in.; typical brake horsepower and torque curves of gasoline engine and Diesel engine showing their characteristics; chart of distillation curves showing relation of gravity of fuel oils with starting and end points.

DROP-FORGING MACHINES

Automatic Gear for. New Automatic Gear for Friction Drop Stamps. Engineer, vol. 151, no. 3926, Apr. 10, 1931, p. 415, 2 figs. B. and S. Massey, Ltd., have introduced new automatic mechanism for actuating pulling cord, much as driver does in hand-controlled stamp.

E

ELECTRIC FURNACES

Annealing. Electric Annealing of Aluminium. Foundry Trade Jl., vol. 44, no. 763, Apr. 2, 1931, p. 244, 1 fig.; see also Metal Industry (Lond.), vol. 38, no. 14, Apr. 3, 1931, p. 364, 3 figs. and Mech. World, vol. 89, no. 2310, Apr. 10, 1931, p. 343. To facilitate precise annealing of aluminum sheets on large scale, General Electric Co., has installed large single-track multi-car type electric annealing furnace which has effective hearth area 24 ft. long by 7 ft. 5 in. wide in works of Aluminum Corp., Dolgarrog, Carnarvonshire; furnace has electric loading of 150 kw., heating elements arranged to ensure phasal balance on 440-volt, 3-phase, 50-cycle supply.

2000 Kw., 75 Ton Furnace Anneals Large Castings. A. G. Hotchkiss. Elec. World, vol. 97, no. 17, Apr. 25, 1931, p. 768, 2 figs. To handle heat treatment of large single-unit steam turbine and electric generator castings properly, General Electric Co. has installed at Schenectady plant 2000 kw. car-bottom type electric annealing furnace with maximum loading capacity of 75 tons; furnace not only handles largest structures now heat treated, but is of sufficient size to accommodate larger machines of future.

Heat-Treating. Elektrische Gluehanlagen in Metallwerken (Electric Heat Treatment Furnaces in Metal Plants), K. Tamele. V.D.I. Zeit., vol. 75, no. 13, Mar. 28, 1931, pp. 383–387, 12 figs. Brief description of various designs of electric resistance furnaces and their operating characteristics; general considerations regarding design and selection.

Melting. The Russ Induction Furnace. Engineering, vol. 131, no. 3404, Apr. 10, 1931, p. 497, 3 figs. Furnace manufactured by Industrie Elektro-Ofen G.m.b.H., Cologne, has normal capacity of 600 kg. and is capable of dealing with all types of non-ferrous metals; important feature is that furnace can be supplied from ordinary mains through Scott-connected transformer.

ELECTRIC MACHINERY

Vibrations. Effects of Vibration on Electrical Machinery and Apparatus, T. Ogawa. Inst. Elec. Engrs. Japan—Jl., vol. 51, no. 1, Jan. 1931, pp. 9–10. Vibrations of high-speed motors are treated, and phenomena of first and higher order critical speeds are discussed; some notices are given of flexible shafts with example of 250-kw., 5000 r.p.m. d.c. motor; torsional vibrations of shaft systems direct-coupled to Diesel engine with one or more armatures; vibration absorbers; effects of vibration and its remedy. (In Japanese, with abstract in English.)

Elastic Supports for Isolating Rotating Machinery, E. H. Hull and W. C. Stewart. Am. Inst. Elec. Engrs.—Advance Paper, no. 76, for mtg. Apr. 29–May 2, 1931, 6 pp., 8 figs. Elastic supports can be made to isolate from two types of disturbance; shocks of any frequency typified by automobile spring suspension, or from vibration of one or several known and constant frequencies; supports described fall in second class; function of these supports is to isolate, not absorb, vibration.

ELECTRIC WELDING

Arc. Inspection Safeguards Quality, R. Kraus. Welding Engr., vol. 16, no. 4, Apr. 1931, pp. 27–31, 14 figs. Inspection and testing methods of Westinghouse Co., with incorrect and correct sketches of welding procedure and layout of weld; testing of welders and dimensions of test specimens. Before Am. Soc. Testing Matls.

Resistance. Applications of Resistance Welding, M. L. Eckman. Welding Engr., vol. 1, no. 4, Apr. 1931, pp. 38–40, 14 figs. Seam welding, flash welding, and spot welding on special machines developed by Federal Machine and Welder Co.; welded tool work; welding high carbon steels; applications to general hardware; forging, bending, annealing, and hardening.

Some Resistance Welding Problems, C. L. Pfeiffer. Am. Welding Soc.—Jl., vol. 10, no. 4, Apr. 1931, pp. 5–11, 11 figs. Analysis of important factors in making resistance welded joints with particular regard to welding of non-ferrous materials; welding processes in use at Hawthorne Plant of Western Electric Co.

ENGINEERING ETHICS

Professional. Professional Ethics and Practices in Engineering, A. Marston. Jl. Eng. Education, vol. 21, no. 8, Apr. 1931, pp. 559–570. It has become duty of engineering colleges to educate their engineering students before graduation in professional ethics and professional practices; professional characteristics of engineering; engineers' license laws; history of professional codes of ethics; professional ethics and professional honor; enforcement of engineering codes of ethics and practice; engineers' fees and salaries; student codes of ethics; ethics of engineering faculties.

ENGINEERING RESEARCH

Great Britain. The Department of Scientific and Industrial Research. Engineering, vol. 131, no. 3404, Apr. 10, 1931, pp. 479–480. Review of 15th Annual Report, price 3s. 6d.; expenditure stands at about £537,000; special attention given for many years to large-scale experiments on low-temperature carbonization has now ceased; resources of Food Investigation Board have been increased by extension of Low-Temperature Research Station at Cambridge; work of Building Research Board and Station; Forest Products Research Laboratory; Radio Research Board; prominent feature in Department's scheme for furthering research is system of maintenance allowances to students in training.

F

FITS

Cylindrical. Cylindrical Fits. Engineering, vol. 131, no. 3404, Apr. 10, 1931, pp. 471–472. Difficulties which relate to standardization of cylindrical work are exemplified by relevant reports of British Engineering Standards Assn.; Preponderance of British firms employ bilateral system; on Continent and in America, prevailing tendency is toward unilateral tolerances; reference is made to two papers before American Society of Mechanical Engineers; C. R. Reiman discussed limits and precision methods in manufacture of high speed automatic printing presses; recent improvements in precision grinding described by R. E. W. Harrison.

FLOW OF FLUIDS

Measurement. Die V.D.I.-Regeln fuer die Durchflussmessung mit genormten Duesen und Blenden (V.D.I. Rules for Measurement of Flow by Means of Standard Nozzles and Diaphragm Orifices), K. Bunte and L. Zipperer. Gas und Wasserfach, vol. 74, no. 11, Mar. 14, 1931, pp. 250–254, 7 figs. Theoretical foundations and description of standardized orifices; discussion on precision measurements; numerical examples.

FLOW OF LIQUIDS

Pipes. Experimentelle Untersuchungen ueber die Entstehung der Turbulenten Rohrstroemung (Experimental Studies on Formation of Turbulent Flow in Pipes), A. Naumann. Forschung auf dem Gebiete des Ingenieurwesens, vol. 2, no. 3, Mar. 1931, pp. 85–98, 29 figs. Review of problem with special reference to work of O. Reynolds, L. Schiller, and W. Tollmien; detailed account of experimental study made in laboratory of applied mechanics and thermodynamics, University of Leipzig, using glass flume and tube; forms of flow at inlet compared with flow at obstruction; initiation of turbulent flow and its relation to Reynolds number; photographic and moving picture records were made of these experiments.

Flow of Liquids in Pipes of Circular and Annular Cross-Sections, A. P. Kratz, H. J. Macintire and R. E. Gould. Univ. Ill.—Eng. Experiment Station—Bul., no. 222, vol. 28, no. 29, Mar. 17, 1931, 28 pp., 8 figs. Relation between friction factor and Reynolds number for two sizes of standard wrought-iron pipe, with two fluids, water and commercial calcium-chloride brine; relation between friction factor and Reynolds number for channels of annular cross-section, with water and commercial calcium-chloride brine; head loss resulting from use of standard cast-iron elbows in pipe lines conveying commercial calcium-chloride brine.

FLUE GASES

Analysis. Graphische Pruefung des Verbrennungsvorgangs (Graphic Study of Combustion Proccess), A. Nahoczky. Waerme, vol. 54, nos. 13 and 14, Mar. 28, 1931, pp. 231–235 and Apr. 4, pp. 250–254, 4 figs. New simple method is shown, with which Ostwald flue-gas diagram can be constructed without knowledge of fuel composition and without calculation; influence of methane and hydrogen in flue gases on use of chart; construction of chart for solid and liquid fuels; gaseous fuels.

Dust-Content Measurement. Messung von Flugstaub in Rauchgasen (Measurement of Dust in Flue Gas), E. Zimmermann. V.D.I. Zeit., vol. 75, no. 16, Apr. 18, 1931, pp. 481–486, 15 figs. Method for measuring dust content of moving flue gases, developed by Berliner Elektrizitaetswerke A.-G.; design of equipment with dust collectors located in flue gas current and without gas current: data on accuracy of measurements.

FORGING

Pressure. Das Dicksche Pressverfahren und die umgekehrt arbeitenden Pressen (Dick Hot-Press Process and Presses Opreating on Inverted Process), O. Busse and C. Busse. Zeit. fuer Metallkunde, vol. 23, no. 4, Apr. 1931, pp. 105–111 and (discussion) 111–113, 18 figs. It is claimed that hydraulic and mechanical pressing of tubes, wire and rods of non-ferrous metals has increased to great extent and almost entirely replaced rolling process; in addition to Dick process, so-called indirect or inverted process of Genders has been developed; differences between these two processes, and results of tests undertaken to improve them; results of experiences.

FOUNDRIES

Materials Handling in. Waste Motion Eliminated in Conveyorized Foundry, R. A. Fiske. Iron Age, vol. 127, no. 16, Apr. 16, 1931, pp. 1258–1263, 10 figs. Materials-handling system and layout of conveyors at new foundry of Bendix-Stromberg Carburetor Co., South Bend; floor plan illustrates how back-tracking is eliminated by proper location of equipment.

Modern Practice in. Some Developments in Modern Foundry Practice, E. Longden. Foundry Trade Jl., vol. 44, nos. 764 and 765, Apr. 9, 1931, pp. 259–262 and Apr. 16, pp. 277–280, 18 figs. Apr. 9: Lanz process; Emmel iron; meehanite iron; Poumay cupola; balanced-blast cupola; Brackelsberg rotary furnace; mechanical cupola-charging plant; sands and refractories. Apr. 16: Core and mold-drying plant; progress in jobbing foundries; continuous costing plants. Before Manchester Assn. Engineers.

FURNACES

Industrial, Design of. Critical Notes on Hydraulic Theory of Flame Furnaces, V. A. Konopassevich. Vestnik Metallopromishlennosti, no. 3, Mar. 1930, pp. 54–64, 3 figs. Critical review on hydraulic theory of furnaces in light of recent studies made in Germany, leading to conclusion that hydraulic theory is not universal infallible method of furnace design; art of builder is important. (In Russian.)

Melting—Pulverized-Coal. The Brackelsberg Furnace at Bingley. Foundry Trade Jl., vol. 44, no. 764, Apr. 9, 1931, pp. 257 and 262, 3 figs. Brackelsberg pulverized-coal furnace installation at Clegg & Howgate, Bingley, Yorkshire; furnace which has nominal capacity of 3 tons, but working one of 4 tons 10 cwt., is used exclusively for manufacture of high-grade malleable cast iron; it consists of 4-ft. 6-in. diam. cylindrical shell formed of steel plate, 15 ft. long, carrying 12-in. acid refractory lining.

G

GALVANIZING

Centrifugal. Centrifugal Process Meets Demand for High-Quality Galvanizing—I and II, K. P. Rolston. Steel, vol. 88, nos. 14 and 16, Apr. 2, 1931, pp. 39–42, and Apr. 16, pp. 39–41, 13 figs. Extracting excess zinc from surface of small galvanized articles is facilitated by centrifugal means used in handling small articles that have been hot-dip galvanized centrifugal process as related to job galvanizer and precautionary measures for minimizing dross formation.

GAS TURBINES

Types and Prospects. Die Gasturbine und die Aussichten zu ihrer Verwirklichung (Gas Turbines and Prospects for Their Use), K. Adloff. Waerme, vol. 54, no. 15, Apr. 11, 1931, pp. 275–277. Gas turbines are divided into three groups, dry, semi-wet and wet turbines; main object of future research should be determination of high temperature-resisting materials and in property of compressed air; basic equations for calculation of gas turbines and auxiliary machines.

GEAR-CUTTING MACHINES

Planer. A Large "Sunderland" Gear Planer. Engineer, vol. 151, no. 3927, Apr. 17, 1931, pp. 438–440, 12 figs. partly on supp. plate. Largest gear planer yet made for generating spur and helical gears on "Sunderland" system, constructed by J. Parkinson and Son, of Shipley, Yorkshire; capable of cutting spur gears up to 15 ft. diam., 24 in. face, double helical gears up to 15 ft. diam., 24 in. face, and single helical or spiral gears either right or left hand, 15 ft. diam. from 10 in. face.

GEARS

Worm—Machining. The Machining of Worms and Threads on Gear Hobbing Machines, K. Glaeser. Machy. (Lond.), vol. 38, no. 966, Apr. 16, 1931, pp. 70–71. Worm and thread generating with gear-shaped cutters; worm and thread cutting with disk-shaped cutters; data on tolerances, speeds, and feeds.

Worm Gear Manufacture, H. Walker. Machy. (Lond.), vol. 38, no. 964, Apr. 2, 1931, pp. 9–12, 9 figs. Gear cutting methods and equipment at works of John Holroyd & Co., Milnrow, especially with reference to hob grinding diagram showing how differential is employed to compensate for tangential feed of hob; worm grinding machine with automatic dividing mechanism; worm-wheel generator with spur gear drive to table.

Spur, Teeth of. Spur Gear Teeth, E. Buckingham. Am. Mach., vol. 74, no. 19, May 7, 1931, pp. 707–710. Relation of factors affecting strength and durability with particular regard to dynamic loads; tables give data on load in lb. per in. of face required to deform teeth the amount of effective error; limiting static tooth load for wear; method of computing dynamic loads and ability of gears to withstand them.

GRINDING WHEELS

Stresses. Ueber den Sapnnungszustand in Schleifscheiben (Stresses in Grinding Wheels), C. Krug and H. Schlechtweg. Maschinenbau, vol. 10, no. 7, Apr. 2, 1931, pp. 236–239, 3 figs. Interpretation of tests made by Norton Co.; methods of calculating stresses and effect of deformation.

H

HYDRAULIC LABORATORIES

Washington, D. C. Work About to Start on National Hydraulic Laboratory, E. C. Hutchinson. Power, vol. 73, no. 16, Apr. 21, 1931, pp. 640–641. Preliminary plans of laboratory; proposed laboratory facilities; original plans changed; European practices studied. Before Washington Soc. of Engrs.

HYDRAULIC MODELS

Testing. Recherches sur la similitude (Research on Similitude), C. Camichel, J. Leclerc du Sablon and L. Escande. Génie Civil, vol. 98, no. 16, Apr. 18, 1931, pp. 39–395, 1 fig. Review of law of hydraulic similitude and summary of experiments, at hydraulic laboratory of Institut Electrotechnique de Toulouse, on models of orifices, spillways, piers, etc.

HYDRAULIC TURBINES

Foundry Practice. A Completely Cast Pelton Water Turbine. Engineering, vol. 131, no. 3407, May 1, 1931, p. 585, 4 figs. Turbine is example of modern foundry technique in that runner is cast in single piece from dry sand cores; result is that this new design enables buckets to be more closely pitched than was possible with old method of bolting buckets to disk, and efficiency of turbine is considerably increased: turbine has been supplied by P. Pitman, Lond., to Glenfield and Kennedy, as emergency valve operating unit for pipe line on Grampian hydroelectric scheme.

Kaplan. Adjustable-Blade Turbine Proves Efficiency at Reduced Loadings, C. L. Dowell. Elec. World, vol. 97, no. 17, Apr. 25, 1931, pp. 766–767, 2 figs. Rescue of 563,000 kw-hr. that would have been lost by fixed-blade turbine is record for 1930 of Kaplan automatic adjustable-blade unit installed in Lake Walk hydro station of Central Power & Light Co.; as far back as 20 years.

Reaction. Vemork Reaction Turbine Operates Under 918-Ft. Head. Power, vol. 73, no. 16, Apr. 21, 1931, p. 630, 3 figs. Advantages of Francis-type wheel to be installed as twelfth unit in Vermork hydro plant of A. S. Rjukanfos, Osla, Norway; design and operating features.

HYDROELECTRIC POWER PLANTS

Design. The Economics of Power Plant Design, H. G. Acres. Elec. News, vol. 40, no. 7, Apr. 1, 1931, pp. 36–38 and 47, 8 figs. Fixed charges and operating expenses should be considered as definite factors in design of all plants; this is well illustrated in design and construction of recently completed development for municipality of Edmundston, New Brunswick.

France. Baubetrieb auf Einer Grossbaustelle. —Bau des Rheinkraftwerks Kembs (Large-Scale Construction Managements—Construction of Kembs Hydroelectric Power Plant of the Rhine), H. Strube and H. Rohde. Bauingenieur, vol. 12, no. 7, Feb. 13, 1931, pp. 115–127, 19 figs. Detailed report on equipment, methods, and organization of work for construction of concrete-lined combined navigation and power canal 9 km. long, 13 m. deep, and 120 m. bottom width, also construction of reinforced concrete structure for housing 6 Kaplan turbines 33,500 hp. each; construction involved 9,000,000 cu. m. of excavation.

Ireland. The Shannon Hydro-Electric Scheme. Engineering, vol. 131, nos. 3399 and 3405, Mar. 6 and Apr. 17, 1931, pp. 340 and 526–529, 5 figs, Mar. 6. Intake building is essentially gravity dam, wing walls of which splay into banks of headrace, and is 405 ft. long by 23 ft. 6 in. wide by 24 ft. high; flow through penstocks is controlled by gates of vertical-lift type; draft tubes are perfectly streamlined, and water flow is therefore steady; two locks at Ardnacrusha are designed to accommodate craft not exceeding 150-ton burden; locks are filled by method employed for first time at Ladenburg, Germany. Apr. 17: Layout of power station at Ardnacrusha; generator hall is equipped with three 38,600-hp. sets; all three turbines are of Francis type; each is supplied through its own penstock, controlled by electrically operated sluice, and connects at its lower end with spiral casing; 110-kv. switchgear is out of doors and mounted at ground level; whole of work was carried out by Siemens-Schuckertwerke A.-G., and Siemens-Baunion G.m.b.H. of Berlin.

Ontario. The Alexander Power Development on the Nipigon River. Engineering, vol. 131, no. 3405, Apr. 17, 1931, p. 529. Hydro-electric Power Commission of Ontario has opened plant at Alexander Landing; quite short and low cofferdams were sufficient to enable work on main dam to be carried on in the dry, whole flow being carried by diversion chanel, 50 ft. wide by 33 ft. deep, in rock 700 ft. long; Francis turbines of 18,000 hp. are installed, with Woodward motor-drive governors; umbrella-type generators are rated at 15,000 kva., with 12,000-volt, three-phase, 60-cycle current, at 100 r.p.m., and 85 per cent power factor.

Sluice Gates. Un Problema di Idraulica (A Problem in Hydraulics), W. Soloman. Energia Elettrica, vol. 8, no. 1, Jan. 1931, pp. 66–67, 1 fig.; see also brief translated abstract in Water and Water Eng., vol. 33, no. 387, Mar. 20, p. 145. Automatic sluice gates are sometimes affected by pendular oscillations, and identical gates in much the same circumstances have behaved in very different way; author simplifies analytic solution of problem by establishing relation between displacements of floating pilot of automatic sluice gate and variations in level of water on upstream side of opening. Translated from Schweizerische Zeitung, Sept. 27, 1930.

Switzerland. Das Rheinkraftwerk Ryburg-Schwoerstadt (The Ryburg-Schwoerstadt Hydroelectric Power Plant on the Rhine), A. Demmel. V.D.I. Zeit., vol. 75, no. 15, Apr. 11, 1931, pp. 441–452, 24 figs. Design and construction of one of Europe's largest hydroelectric plants, having hydraulic capacity of 140,000 hp. and output of 600,000,000 kw-hr. per annum; details of headworks, intakes, vertical Kaplan turbines, electrical equipment, etc.; features of cofferdams and caissons used in construction of plant.

I

IMPACT TESTING

Kravz-Tarnavsky Effect A Special Type of Impact Deformation of Steel, N. Davidenkov and I. Mirolyubov. Vestnik Metallopromyshlennosti, no. 9–10, Sept.-Oct. 1930, pp. 132–145, 15 figs. Experimental study of Kravz-Tarnavsky effect; analysis of factors leading to formation of hard streak; thermal effect of impact; properties of impact streak; effect of heat treatment on formation of impact streaks. Report from Physico-Technical Institute of Russia, in Leningrad. (In Russian.)

INDUSTRIAL MANAGEMENT

Cost Accounting. An Adequate Tool Shop System, F. W. Hack. Modern Machine Shop, vol. 3, no. 10, Mar. 1931, pp. 20, 22, 24, 26, 30, and 32, 7 figs. Accounting and production record system particularly suited for job shop; estimate records; bill of materials and job tickets.

Bestimmung der realen Herstellungskosten (Determination of Actual Production Costs), C. Nunn. Maschinenkonstrukteur, vol. 64, no. 6, Mar. 25, 1931, pp. 66–68, 3 figs. Separation of total costs according to suggestion of VDMA and VDI and derivation of price formula and cost diagram which represent graphically all changes of wages, price of materials and other costs for all degrees of capacity; practical examples illustrate application of formulas.

Der Widerstreit der Verrechnungspreiszwecke in der Praxis (Conflict in Practice of Price Balancing), H. Kreis. Archiv fuer das Eisenhuettenwesen, vol. 4, no. 9, Mar. 1931, pp. 449–453. Review of literature on price-balancing problem; advantages and disadvantages of four different kinds of prices, namely production-cost price, standard price, market price, and proportional price; different purposes of price balancing are classified and discussed.

Die Verrechnungspresifragen im Rahmen des industriellen Verrechnungswesens (Problem of Price Balancing in the Field of Industrial Cost Accounting), A. Hempelmann. Archiv fuer das Eisenhuettenwesen, vol. 4, no. 9, Mar. 1931, pp. 443–448. Meaning and historical development of problems of price balancing; market prices and net costs; adaptation of price balancing to cost-accounting systems.

Die planmaessige Unkostenbewirtschaftung in der Giesserei (Systematic Cost Accounting in Foundries), W. Bremer. Giesserei, vol. 18, no. 14, Apr. 3, 1931, pp. 277–281, 2 figs. Labor and materials costs; tables and charts as aid in systematic supervision of foundry overhead costs and in elimination of causes of wasters; budget control of wage and materials costs.

Production Costs. D. S. Hazen. Factory and Indus. Mgmt., vol. 81, no. 5, May 1931, pp. 797–798, 2 figs. Cost-accounting system developed to control production costs and inventory stock by small plant.

The Control of Non-Productive Costs, H. W. Beton. Maintenance Eng., vol. 89, no. 4, Apr. 1931, pp. 194–198. Outline of method which detects unbalance immediately; table of non-productive time analysis; summary of plant engineer's department time consumption for one month; table of budgets for productive and non-productive departments.

Measurement. A New Measure of Management. W. S. Ford. Factory and Indus. Mgmt., vol. 81, no. 5, May 1931, pp. 777–779, 1 fig. Development of Ford-rating chart based on rule of seven and nine, i.e., seven standards for rating future prospects and forecasting probable earnings and nine laws of management which must be observed if earnings are to be maintained over successive periods of prosperity and depression.

Production Control—Records. Eliminating Wide Fluctuation in Operating Schedules. Iron Age, vol. 127, no. 17, Apr. 23, 1931, pp. 1350–1352, 2 figs. Methods of production scheduling in ammunition manufacturing division of Remington Arms Co., Inc., Bridgeport, Conn.

Production Control of Interchangeable Parts. Iron Age, vol. 127, no. 19, May 7, 1931, pp. 1512–1518, 15 figs. Operation of record system for production scheduling in plant manufacturing office appliance machines; master operation sheet has been developed which specifies in detail every operation part is to undergo; close supervision of stocks of finished parts and of subassemblies, in interest of avoiding heavy inventory tie-up while still assuring adequate supplies to carry manufacture forward.

Small Plants. Has the Small Plant a Future, B. Finney. Iron Age, vol. 127, no. 19, May 7, 1931, pp. 1499–1501 and 1518. Various examples illustrate advantages of small-plant organization.

INDUSTRIAL PLANTS

Maintenance Costs. Variations in Maintenance Costs and Procedure, E. V. Stoody and G. I. Ross. Maintenance Eng., vol. 89, no. 4, Apr. 1931, pp. 158–161, 5 figs. Chart and data showing maintenance ratios in 20 typical plants; wide dispersion of ratios indicates that there is vast field for improvement in general treatment of maintenance problem.

INDUSTRIAL PSYCHOLOGY

Standardization and. Normung und Psychotechnik (Standardization and Psychology), E. Ganzenhuber. Maschinenbau, vol. 10, no. 7, Apr. 2, 1931, pp. 250–252, 2 figs. Study of importance of arranging terminology, symbols and code markings of materials according to definite plan, in order to eliminate unnecessary thinking and reduce sources of errors; based on experiments, possibility is shown of establishing uniform code and marking systems.

INDUSTRIAL TRUCKS

Lift, Electric. Umstellung eines Betriebes auf Hubkarrenfoerderung (Changeover of Operation to Lift Truck Transportation), H. Krippendorff. Maschinenbeau, vol. 10, no. 7, Apr. 2, 1931, pp. 248–250, 9 figs. Study of efficiency of electric lift-truck operations with particular regard to saving of space, better load factors and maintenance expenses.

INTERNAL-COMBUSTION ENGINES

Air-Cooled. Air Cooling of Engines, C. J. Vogt and L. M. K. Boelter. Motive Power, vol. 2, no. 3, Mar. 1931, pp. 13–17, 12 figs. Design and constructional features of air-cooled cylinders: heat transfer; diagrammatic representation of air flow around cylinder at different air speeds; cross-sectional views of Model M, Briggs and Stratton, air-cooled, single-cylinder gasoline engine developing 1 hp. at 2200 r.p.m. showing method of controlling air flow by shrouding.

Combustion in. Das Klopfen von Zuendermotoren (Detonation in Spark Ignition Engine), K. Schnauffer. V.D.I. Zeit., vol. 75, no. 15, Apr. 11, 1931, pp. 455–456, 5 figs. Investigation of flame-propagation phenomena by means of electric measuring methods developed at DVL Laboratory; oscillograms of pressure characteristics show that detonation may be caused by simultaneous ignition of part of mixture; methods permit determination of mixture quantity still contained in cylinder at start of knock.

Detonation. Zur Erklaerung des Klopfens in den Vergasermotoren und der Wirkung der Antiklopfmittel (Study of Detonation in Carburetor Engines and Effect of Anti-Knock Compounds), J. Lorentzen. Zeit. fuer Angewandte Chemie, vol. 44, no. 7, Feb. 14, 1931, pp. 130–136, 12 figs. Experimental investigation of nature and causes of knocking; effect of admixture of anti-knock compounds.

[See also AIRPLANE ENGINES; AUTOMOBILE ENGINES; DIESEL ENGINES; OIL ENGINES.]

L

LATHES

Change Gears. Beitrag zur Ermittlung des Zweckmaessigsten Getriebeplanes von Drehbank-Spindelkaesten (Determination of Most Suitable Layout of Change Gears for Lathes), I. Irtenkauf. Werkstattstechnik, vol. 25, no. 7, Apr. 1, 1931, pp. 177–183, 10 figs. Practical examples illustrate fundamental considerations and requirements from standpoint of manufacture and reliability in operation; determination of gear ratios and steps.

LIGHTING

Industrial. Good Lighting—An Executive Problem, M. Warren. Indus. and Eng. Chem., vol. 23, no. 5, May 1931, pp. 512–516, 9 figs. Decreased cost of production, reduced spoilage, fewer accidents and higher morale among workers are few of things which good lighting claims it can bring to factory; these claims are supported by actual plant data; voltage real factor in illumination design; methods of lighting; reflecting equipment; intensities; spacing, mounting height, and lamp size; special-purpose lighting; color matching or identification; maintenance; cost of artificial light.

LOCOMOTIVES

Articulated. Baltimore & Ohio's New Mallet Locomotive. Ry. Jl., vol. 37, no. 4, Apr. 1931, p. 18, 1 fig. Design features of experimental locomotive undergoing tests on Cumberland division; cylinders 23 by 30 in.; driving wheels 70 in.; boiler pressure 250 lb. per sq. in.; tractive force 90,000 lb.; total engine wheelbase 56 ft. 0 in.; total engine weight 465,000 lb.

Boilers—Design. Calculating the Working Pressure of a Locomotive-Type Boiler. Power, vol. 73, no. 15, Apr. 14, 1931, pp. 600–601, 2 figs. Method of calculating working pressure; calculating crown-sheet strength.

Diesel—Design. Eine neue Loesung des Problems der Diesellokomotive mit unveraenderbarem Antrieb (New Solution of Problem of Diesel Locomotives With Nonvariable Drive), K. Sanden and H. Wohlschlaeger. Organ fuer die Fortschritte des Eisenbahnwesens, vol. 86, no. 7, Apr. 1, 1931, pp. 167–171, 5 figs. Critical review of performance characteristics of design in which revolution ratio between engine and driving wheels is constant; heat economy; starting and pulling ability.

Diesel-Electric. The B and W Diesel-Electric Locomotive. Motive Power, vol. 2, no. 4, Apr. 1931, pp. 30–32, 5 figs. Danish firm standardized on six sizes of Diesel-electric locomotives for switching and mainline service ranging from 200 to 1200 hp.; design, construction, and operating features of 200-hp. B and W. Diesel-electric locomotive; Diesel engines of two-stroke cycle, airless-injection type; high-speed, single-acting trunk systems of light-weight construction; sectional elevation and plan views; performance, data.

Gasoline-Electric. Gasoline-Electric Locomotive. Thousand Islands Railway. Can. Ry. and Mar. World, no. 398, Apr. 1931, pp. 201–202, 3 figs. Advantages of gasoline-electric locomotive drive over Diesel and steam; locomotive design and specifications; Ricardo head, girder type crankcase and truncated cylinders; bore, 5 in.; stroke, 5¾ in.; displacement, 677 cu. in.; performance characteristics of gasoline engine of type in gasoline-electric locomotive.

High-Pressure. Les locomotives a haute pression (High-Pressure Locomotives), P. Magnée. Revue Universelle des Mines, vol. 74, no. 5, Mar. 1, 1931, pp. 139–148, 13 figs. Present status of high-pressure locomotives; description of certain types, including Witerthur 60-atm. 2-6-2 type; Schmidt-Henschel 60-atm. type 4-6-0; Schwartzkopff-Loeffler 120-atm. 4-6-2 type; Gresley-Yarrow 31-atm. 4-6-4 type; Fowler 63-atm. 4-6-0 type; Krupp 60-atm. turbine locomotive; and Maffei 225-atm. turbine locomotive; it is concluded that reciprocating-engine locomotives with exhaust have at present advantage over turbine locomotives which are still in experimental stage.

Passenger—Canadian Pacific. C.P.R. 4-6-4 Type Locomotives Give Good Performance. Ry. Age, vol. 90, no. 13, Mar. 28, 1931, pp. 617–619, 5 figs. Smooth running and easy-riding qualities feature engine which can be operated at unusually high sustained speeds; performance in road service; features of design and construction; cylinders 22 by 30 in.; driving wheels 75 in.; boiler pressure 275 lb. per sq. in.; total engine weight in working order 350,900 lb.; total engine wheel base 39 ft. 6 in.; rated maximum tractive force 45,250 lb.

Plants—Machine Tools. Sixty-Foot Locomotive Beds Made in One Piece, C. O. Herb. Machy. (N. Y.), vol. 37, no. 9, May 1931, pp. 649–652, 6 figs. Layout and operation of machine tools for machining locomotives and tender beds at plant of General Steel Casting Corp., Eddystone, Pa.

Spark, Arrester, New. Improved Spark Arrester Developed on the Northern Pacific. Ry. Age, vol. 90, no. 17, Apr. 25, 1931, pp. 813–814, 2 figs. Designed to eliminate sparks under all load conditions, without use of netting or increased back pressure; extensive tests on Northern Pacific, including two conducted by Forestry Department of United States Department of Agriculture, indicate that new spark arrester prevents any sparks leaving stack of sufficient size to start fire on right of way; tabular test results.

Switching. Ten-Wheel Switcher With Aluminum Rods. Ry. Age, vol. 90, no. 16, Apr. 18, 1931, pp. 759–760, 1 fig. Aluminum alloys extensively used in details of Alton and Southern locomotive recently placed in transfer service; cylinders 28 by 30 in.; driving wheels 57 in.; boiler pressure 230 lb. per sq. in.; rated tractive force 80,500 lb.; total engine and tender wheel base 66 ft. 11⅛ in.; total engine and tender weight in working order 559,800 lb.

Valve Gears. L'Application aux locomotives à vapeur des systèmes de distribution à soupapes (Application of System of Valve Distribution to Steam Locomotive), H. Martin. Génie Civil, vol. 98 no. 14, Apr. 4, 1931, pp. 333–337, 13 figs. Comparison of design and performance of various systems using rotary cam poppet valve gear, including Walschaerts, Dabeg, Renaud, and Caprotti.

Valve Gear and L. and N. E. Ry. High-Pressure Locomotive. Locomotive, vol. 27, no. 464, Apr. 15, 1931, pp. 113–114, 2 figs. Design and operating features of special valve gear employed on high-pressure locomotive number 10,000; illustrated description of inside and outside valve motions.

LUBRICANTS

Cutting. Extreme Variation in Cutting Fluid Practice Brought Out by Survey, J. Geschelin. Automotive Industries, vol. 64, no. 18, May 2, 1931, p. 688–692, 1 fig. Analysis and correlation of data representing current practice in 36 large automotive manufacturing plants; percentage reporting soluble oils in steels, malleable iron, aluminum alloy.

LUBRICATION

Friction Coefficients. Au sujet du Coefficient de Frottement (Coefficient of Friction), C. Hanocq and J. Tilman. Revue Universelle des Mines, vol. 5, no. 7, Apr. 1, 1931, pp. 194–195. Résumé of authors' previous work; review of different theories on fluid friction and research work of author, Stribeck, Schneider, and others; viscous friction studied by Tilman; formulas for calculating coefficient of friction.

M

MACHINE TOOLS

Design. Der Starrheitsgrad von Werkzeugmaschinen erlaeutert am Beispiel einer Gewindewalzmaschine (Rigidity of Machine Tools Interpreted by Example of Thread-Rolling Machines), W. Reichel. Maschinenbau, vol. 10, no. 8, Apr. 16, 1931, pp. 265–270, 16 figs. Need for data on degree of rigidity of machine tools in addition to degree of accuracy; determination of rigidity of thread-rolling machine and comparison of result with theoretical calculation; rigidity of different German thread-rolling machines.

Hydraulic Drive. The Application of Hydraulics to Machine Tools, G. W. Betteridge. Mech. World, vol. 89, nos. 2308 and 2309, Mar. 27, 1931, p. 299, and (discussion) Apr. 3, pp. 319–321. Main advantages of hydraulic feeds over mechanical feeds are summarized under following heads: flexibility; their cushioned effect on tools; ease of control and safety factor; lower power consumption.

Manufacture—Standardization. Standardization in the Wanderer Machine Tool Works at Siegmar, Germany, F. J. Schlink. Am. Standards Assn.—Bul., no. 60, Apr. 1931, pp. 9–10. Firm's factory standards include many of standards of Deutscher Normenausschuss, German national standardizing body, which are used just as they have been published by that organization; others have been especially edited to include Wanderer identification numbers or to omit details of sizes not needed in factory's production; hardness-testing standards needed.

MACHINERY

Vibrations. See ELECTRIC MACHINERY.

MATERIALS HANDLING

[See FOUNDRIES; STEAM POWER PLANTS, Coal Handling.]

MEASURING INSTRUMENTS

Precision. Precision Measuring Instrument. Engineering, vol. 131, no. 3404, Apr. 10, 1931, p. 500, 2 figs. At Leipzig Fair, Fortuna-Werke Spezialmaschinenfabrik A-G., of Stuttgart-Cannstadt, exhibited number of examples of their precision measuring instruments, many of which embody Hirth minimeter; interesting application of minimeter is shown in combination instrument for testing distance between gudgeon-pin hole and piston head or pistons of internal-combustion engines, as well as whether axes of this hole and of piston are truly at right angles.

METALS

Cleaning. Electrolytic Bath Cuts Cleaning Costs, D. E. Williard. Black and White (Metal Edition), vol. 3, no. 6, May 1931, pp. 18–23. Advantages derived from use of electric current in cleaning bath; equipment; tank construction; direct and reverse cleaning; cleaning solutions.

Cutting. Thermodynamic Theory of Metal Cutting. N. A. Safonov. Vestnik Metallopromishlennosti, nos. 2 and 9–10, Feb. 1930, pp. 45–64, and Sept.-Oct., pp. 16–42, 17 figs. Theoretical study reviewing experimental work by Taylor and others; assumptions for construction of theory establishing relationship between Taylors' experimental results and modern views of molecular physics as to atomic heat capacity. (In Russian.)

Machinability. Neue Untersuchungen zur Schnittheorie und Bearbeit-barkeit (New Studies of Cutting Theory and Machinability), F. Schwerd. Stahl und Eisen, vol. 51, no. 16, Apr. 16, 1931, pp. 481–491, including discussion, 24 figs. Review of previous research work; results of tests on open-hearth steel, together with cast iron, aluminum, copper, and brass with different cutting profiles and speeds.

O

OIL ENGINES

Two-Cycle. Mechanical Losses in Two-Cycle Oil Engines, A. Petters. Power, vol. 73, no. 17, Apr. 28, 1931, pp. 660–661, 1 fig. Tests indi-

cate that three rings per piston are enough and that addition of more rings decreases compression; curves illustrating mechanical losses; results of high compressions.

OPEN-HEARTH FURNACES

Design. Design of Open-Hearth Ports, V. Balabanov. Iron Age, vol. 127, no. 16, Apr. 16, 1931, pp. 1254–1257 and 1273, 3 figs. Review of progress with particular regard to considerations of velocity and volume of gases used as fuels in open-hearth furnace, and of velocity and volume of waste products of combustion going to stack.

The Terni O.H. Furnace and Port, F. Fiorelli. Iron and Steel Industry, vol. 4, no. 7, Apr. 1931, pp. 249–250, 2 figs. Principal characteristic of Terni type of open-hearth furnace is improvement made in air and gas ports, so as to render them capable of varying nature and intensity of combustion during various phases of open-hearth process.

Practice. Controls Open-Hearth Reversal by Temperature Difference, H. R. Simonds. Steel, vol. 88, no. 19, May 7, 1931, pp. 53, 55 and 57, 5 figs. Experiences with automatic-reversal equipment built by Leeds & Northrup Co., Philadelphia; method of control does not prevent temperature in regenerative system of furnace from going too high or too low.

P

PIPE

Cast Iron—Manufacture. Making Pipes in Green Sand, Jackson. Foundry Trade Jl., vol. 44, no. 763, Apr. 2, 1931, pp. 237–238, 7 figs. Reference only made to special and standard connections; interchangeability of patterns; straight pipes; bend pipes; making siphon pots; molding details. Before Institution of British Foundrymen.

POLISHING

Machine. An Experimental Study of Metal Polishing by Flexible Polishing Wheels, E. M. Baker and G. E. Holbrook. Electrochem. Soc.—Preprint, no. 59-31 for mtg. Apr. 23–25, 1931, pp. 323–338, 9 figs. Apparatus designed and built for experimental study polishing by flexible polishing-wheels, general procedure of laboratory tests, experimental data obtained in study of effect of variations in pressure upon performance of wheels, of variations in grain-screen analysis and glue concentration upon performances, changes of performance of wheel, effect of applying thin film of glue to periphery of wheels after all grain has been applied.

Successful Machine Polishing of Metals and Metal Products, R. T. Kent. Iron Age, vol. 126, no. 22, Nov. 27, 1930, pp. 1598–1599 and 1665–1666; see also abstract in Foundry Trade Jl., vol. 44, no. 767, Apr. 30, 1931, p. 308. Various factors which must receive consideration; peripheral speed of polishing wheels should be held as closely as possible to 7500 lin. ft. per min.; different jobs require different depths of cushion and different wheel densities; vibration in polishing wheel produces chatter marks in article polished. Before the National Metal Congress, Chicago.

PRESSES

Blanks for. The Graphical Determination of Blank Sizes for Round-Cornered Cups, A. Alison. Machy. (Lond.), vol. 38, no. 966, Apr. 16, 1931, pp. 76–78, 1 fig. Calculation and application of chart giving blank sizes for cups with rounded corners, illustrated by examples.

Weighing Thin Sheets to Measure Thickness. Machy. (Lond.), vol. 37, no. 961, Mar. 12, 1931, pp. 775–777, 3 figs. Design and operation of punch-press and die built by Aluminum Research Laboratories of Aluminum Co. of America for cutting foil 0.00025 in. thick with edges clean and free from burrs.

Drawing. "Slow Draw" Motion Increases Crank Press Operating Speeds, W. P. Blake. Iron Age, vol. 127, no. 16, Apr. 16, 1931, pp. 1251–1253, 4 figs. Application of modified Whitworth motion to crank presses produces uniform velocity of punch on downstroke and quick return on upstroke; practical examples illustrate advantages of drive for redrawing, broaching, and burnishing operations.

PRESSURE VESSELS

Design. Pressure Vessel Designer Must Meet New Needs, G. F. Wieser. Chem. and Met. Eng., vol. 38, no. 4, Apr. 1931, pp. 243–244, 1 fig. Improvement in design, use of better fabricating processes, availability of new alloys, and more extensive research data on behavior of carbon steels, are outstanding factors contributing to present progress of pressure-vessel manufacture; it is realized that future developments in chemical processes will require equipment to withstand operating conditions even more severe than those encountered of today.

High-Pressure. Designing Equipment for High Pressures, B. F. Dodge. Chem. and Met Eng., vol. 38, no. 4, Apr. 1931, pp. 241–243. Practically only metals that come into consideration for pressure-sustaining shell of high-pressure vessels are steels; problems in design of large welded pressure vessels, such as those used in petroleum industry; it is evident that much more fundamental work must be done on properties of materials at high pressures and at elevated temperatures before design of equipment to withstand such severe conditions and to operate economically can be said to rest on sound, scientific basis.

PUMPING PLANTS

New Brunswick, N. J. The Electric Pumping Station for New Brunswick, A. Arkinson. Am. Water Works Assn.—Jl., vol. 23, no. 4, Apr. 1931, pp. 509–513. Description of recently completed plant equipped with 8 in. centrifugal driven by 200-hp. synchronous motor, with capacity of 4 million gal., two 12 in. centrifugal pumps driven by 300-hp. synchronous motors with capacity of 6,000,000 gal. each; total capacity is 16 m.g.d. at highest head; water is pumped through two pumping mains 8000 ft. to reservoir with static head of 123.5 ft.; cost of pumping by electricity is $14.72 per million gal.

PUMPS, CENTRIFUGAL

Testing. Hilfsmittel zur Beobachtung und Messung an umlaufenden Kreiselraedern (Aids to Observation and Testing of Rotating Centrifugal Pumps), A. Closterhalfen. Forschung auf dem Gebiete des Ingenieurwesens, vol. 2, no. 2, Feb. 1931, pp. 52–56, 11 figs. Features of revolving mercury pressure meter, methods of determining speed of revolving rotors, with particular reference to optical instruments.

R

RAIL MOTOR CARS

Diesel. Dieseltriebwagen imt quergestellten Motoren (Rail Motor Cars With Transversal Arrangement of Diesel Engine), K. Friedrich. Organ fuer die Fortschritte des Eisenbahnwesens, vol. 86, no. 7, Apr. 1, 1931, pp. 176–181, 8 figs. Design and performance data of rail motor car with two MAN engines developing 75 hp. each at 1200 r.p.m.

Storage-Battery. Automotrices électriques a accumulateurs en Europe (Electric Storage Battery Operated Rail Motor Cars in Europe), P. Lo Balbo. L'Industrie des Voies Ferrees et des Transports Automobiles, vol. 25, no. 290, Feb. 1931, pp. 57–67, 13 figs. Development of European systems using storage-battery drive, with data on design and electric characteristics of principal types of batteries; data on operating experiences in Germany.

REFRIGERATING MACHINES

Absorption. Versuche an einer intermittierenden Absorptions-Kaelte-maschine (Tests on Intermittent Absorption Refrigerating Machine), H. R. Mannesmann and M. Kirschner. Zeit. fuer die Gesamte Kaelte-Industrie, vol. 38, no. 3, Mar. 1931, pp. 38–42, 2 figs. Review by M. Kirschner of work by H. R. Mannesmann on properties of wet intermittent-absorption machines, based on theoretical calculations and practical tests; history of development; basic principles of design; results of tests.

ROLLING MILLS

Blooming-Mill Practice. Ueber das Auswalzen von Sonderstaehlen auf Blockstrassen mit Kalibrierungsbeispielen (Rolling of Special Steels on Blooming Mills With Examples of Roll Drafting), O. Emicke. Stahl und Eisen, vol. 51, no. 14, Apr. 2, 1931, pp. 417–428, 12 figs. Influence of deformation resistance, heat conductivity and rolling temperature; extension of decarburization zone; ingot molds and weights; design of two-high reversing and three-high blooming mills; differences between special-steel and ingot-steel rolling.

Sheet Mills—Design. Calculating Concavity and Cross for Sheet Mill Rolls, H. G. Wible. Iron Age, vol. 127, no. 17, Apr. 23, 1931, pp. 1353–1354, 2 figs. Dressing sheet or tin mill rolls by topping method in lathe, and its relationship to same work done in roll grinder; formula by which it is possible to figure exact concavity in pair of rolls that has been given known cross.

S

SCREW THREADS

Strength. Festigkeitseigenschaften kaltgewalzter Schrauben (Strength Properties of Cold-Rolled Screws), W. Reichel. V.D.I. Zeit., vol. 75, no. 15, Apr. 11, 1931, pp. 457–459, 6 figs. Experiment shows that strength of rolled screws is approximately 20 per cent higher than that of cut screws, because fibers of materials are not cut through; methods of measuring heat during rolling process by thermocouple.

SHEET METAL

Specifications. Standard Thicknesses, Weights, and Tolerances of Sheet Metal (Customary Practice). U. S. Bur. Standards—Cir., no. 391, Mar. 24, 1931, 32 pp. Usual practice of American manufacturers with regard to stock thicknesses or weights of sheets and plates of common metals and alloys; various gages for sheet metal in use in United States; specific applications of these gages to various metals and alloys; gages or stock lists for sheet metal widely used in Europe; manufacturing tolerances adopted by American technical societies, manufacturers' association, and standardizing bodies, or used by leading manufacturers.

Steel—Testing. Some Notes on the Alternating Bend Test for Thin Mild Steel Sheets, J. C. Godsell. Sheet Metal Industries, vol. 4, no. 12, Apr. 1931, pp. 1026, 1028, and 1030–1032, 6 figs. Relation between bend values and thickness of test strips; relation between bend values and radius of bend; influence of annealing on bend values of thin mild steel sheets; influence on bend values of cooling from annealing temperature; descriptions and analysis of sheets used.

SPEED REDUCERS

Reduction Gears. The "Pericentric" Reduction Gear. Engineer, vol. 151, no. 3927, Apr. 17, 1931, p. 442, 1 fig.; see also Engineering, vol. 131, no. 3405, Apr. 17, 1931, p. 513, 3 figs. New method of constructing double and triple reduction-gear units, introduced by D. Brown and Sons, Huddersfield; in this gear lay shafts of double-reduction drive are duplicated; essential feature of system lies in manner in which loads on two lay shafts are equalized at all times and under all loads without use of springs or flexible gears.

STANDARDIZATION

Numerical Basis for. Die Grosszahl-Forschung als Grundlage fuer die Schaffung von Pruef- und Toleranzvorschriften (Large-Number Statistics as Basis for Establishing Rules for Testing and Tolerances), K. Daeves. Maschinenbau, vol. 10, no. 7, Apr. 2, 1931, pp. 233–236, 7 figs. Study of effect of close tolerances on waste and prices; analysis of factors controlling uniformity and quality; shortcomings of present standards and application of large-number statistics in order to reduce friction between producer and consumer.

STEAM

Tables of Properties. Die Zustandsgroessen des Wassers im Bereich von 10 deg. bis 500 deg. und vom Saettigungsdruck bis 300 at (Characteristics of State of Water from 10 to 500 deg. cent. and From Saturation Point up to 300 Atmos.), M. Trautz and H. Steyer. Forschung auf dem Gebiete des Ingenieurwesens, vol. 2, no. 2, Feb. 1931, pp. 45–52, 9 figs. Experimental investigation of specific volume of liquid water between 150 atmos. and 300 atmos. at temperatures of 10 to 370 deg.; determination of heat content of water and steam over same pressure range between 10 and 500 deg. cent.; calculation of product of Thomson-Joule effect and specific heat; heat content and specific heat at constant pressure.

STEAM-ELECTRIC POWER PLANTS

Germany. Dampfkraftwerk Else bei Schwandorf (Steam-Electric Power Plant Else near Schwandorf), A. Schmidt. Waerme, vol. 54, no. 13, Mar. 28, 1931, pp. 238–239, 2 figs. Steam plant erected by Bayernwerk A.G. as addition to its system of hydroelectric power plants; work was designed and carried out by A.E.G.; installed capacity of plant is 180,000 kw.; two turbines of 27,500 kw. each, are 4-stage double-casing live-steam condensation type with 3000 r.p.m., each connected to three-phase generator of 37,500 kva. capacity; steam is generated in 8 vertical-tube boilers, each with heating surface of 900 sq. m., fired with Schwandorf lignite.

Die Bauanlagen des Grosskraftwerkes West der Berliner Staedtischen Elektrizitaetswerke Akt.-Ges. (Structures of the West Power Plant of the

Berlin Staedtische Elektrizietaetswerke Akt.-Ges.), K. Bernhard, V.D.I. Zeit., vol. 75, no. 14, Apr. 4, 1931, pp. 413–420, 21 figs. Design and construction of boiler house, reinforced-concrete smoke stacks, up to 64 m. in height, machinery building and pumping station of one of Europe's largest steam-electric power plants; details of steel-frame construction.

Great Britain. Kristall the New Leeds Power Station. Elec. Rev., vol. 108, no. 2783, Mar. 27, 1931, pp. 539–543, 13 figs. Station has been laid out for ultimate plant capacity of 150,000 kw. limit for initial section being 50,000 kw.; it is to be base-load station working in conjunction with grid; average weekly coal consumption up to present has been 1.55 lb. per kw-hr. using coal of about 12,150 B.t.u. per lb. calorific value, resulting in thermal efficiency of about 20 per cent, with very poor load factor; during Feb. maximum load on station was 16,000 kw., and kw-hr. generated totaled 3,498,700.

The Deptford West Power Station of the London Power Company, Limited, C. S. Berry, H. P. Gaze, C. E. H. Verity. Instn. Civil Engrs.—Minutes of Proc., vol. 23, no. 4820, 1930–1931, 59 pp., 40 figs. partly on supp. plates. Complete details of design, steam, electric, and auxiliary equipment of plant at present containing 8 boiler units at 75,000 to 95,000 lb. per hr. and 4 at 100,000 to 130,000 lb. per hr., two 25,000-kw. and three 35,000-kw. turbine generators; operating pressure 350 lb. at 750 deg. fahr. generator voltage 6600 at 1500 r.p.m.

STEAM POWER PLANTS

Coal Handling. Conveyor Practice in Coal Handling, E. J. Tournier. Indus. Transmission and Conveying, vol. 38, no. 4, Apr. 1931, pp. 8–12, 8 figs. Factors determining selection of coal-handling equipment; design, construction, and operation of various coal-handling conveyor systems; calculation of horsepower required.

Design. Gegenwartsaufgaben im Kraftwerkbau (Modern Problems in Steam Power Plant Consumption), F. Muenzinger. V.D.I. Zeit., vol. 75, no. 17, Apr. 25, 1931, pp. 505–510, 19 figs. Study of factors contributing to progress and relative importance principal trends; improvement of operating methods and machinery; improvement of materials and higher load factors; use of greater units; construction and organization methods; reducing cost of installation.

Modern Power Basic Principles, Design and Application—XII, F. T. Morse. South Power Jr. vol. 49, no. 4, Apr. 1931, p. 55–60, 5 figs. Design of steam power plant and system based upon vapor cycle; direct tie between physical design and theoretical cycle is heat-balance diagram and study made of it by power engineer, by which various possibilities of heat transformation are economically adapted to limitations of equipment design; vapor cycles vary from theoretical ideal to practical approximation; vapors for heat engines; Carnot cycle; trend of central station progress; trend of industrial-plant practice.

Industrial. Power for the Ford River Rouge Plant. Blast Furnace and Steel Plant, vol. 19, nos. 3 and 4, Mar. 1931, pp. 431–432 and 454, and Apr., pp. 564–566, 4 figs. New boiler installation, consisting of two double-set Ladd boilers, each furnishing water-heating surface of 50,000 sq. ft.; steam-generating capacity is 700,000 lb. per hr. for each boiler, with boiler pressure of 1400 lb.; operating data with particular regard to 110,000 kw. steeple compound turbine-generator; pressure at throttle will be 1215 lb. absolute and temperature of steam 725 deg. fahr.; design of auxiliary equipment and new water tunnel with daily capacity of 913,600,000 gal.

Operation. Betriebserfahrungen mit der 35-atue-Anlage im Kraftwerk Simmering der Wiener Elektrizitaetswerke (Operating Experiences With 35 Atmosphere Simmering Plant of Vienna Electric Power Company), F. Stipernitz. Sparwirtschaft, vol. 9, no. 2, Feb. 1931, pp. 49–57, 5 figs. Design and operation of steam power plant equipped with 15,000- and 20,000-kw. turbines; average heat consumption of 4200 calories per kw-hr. for load factor of 1/2; details of coal preparation and grinding equipment for pulverized coal.

Pipe Lines. Prioform Heat Insulation. Engineering, vol. 131, no. 3405, Apr. 17, 1931, p. 522. System of insulation for high-pressure steam pipes and other apparatus, developed by Deutsche Prioform Werke, G.m.b.H., of Cologne; insulating medium is slag wool treated in such way as to resist disintegration, crumbling, and packing; shell or casing is strong mechanically to withstand pressure, and also resistant to chemical corrosion, but able to accommodate itself to expansion by heat; structure supporting shell consists of frames built up of hoops and rods in fashion of cage.

Station Piping. Nat. Elec. Light Assn.—Pub., no. 117, Apr. 1931, 12 pp., 17 figs. This report summarizes theory of pipe system expansion and flexibility, and gives operating experiences with piping; data on flexibility, specifications, expansion joints, heater drainage, gate valve trim, remote control of valves, flange joints; operating companies' statements; available specifications for piping, valves, fittings, and bolting material; manufacturer's statement.

Power and Process. Designing Power Services for Process Plants, W. S. Johnston. Chem. and Met. Eng., vol. 38, no. 4, Apr. 1931, pp. 238–241, 3 figs. Factors to be considered in design; establishment of one or more pressures for process purposes should be at low pressures as processes and rapidity of production permit; if assumed that majority of industrial processes require steam at 125 lb. pressure or less, it is probable that high-pressure steam will be most valuable as producer of by-product energy rather than directly in process applications; waste gases utilized in waste-heat boilers; direct application of high-pressure steam.

STEAM TURBINES

Operation. Turbines. Nat. Elec. Light Assn.—Pub., no. 078, Aug. 1930, 79 pp., 100 figs. Turbine operating data; operating companies' statements on two 160,000-kw. units at Hell Gate station; 110,000-kw. unit at Hudson Avenue station; 160,000-kw. unit at East River station; operating experience with 165,000-kw. unit at Philo operation of 94,000-kw. unit at Long Beach; installation of 1400-lb. unit in San Antonio; tests of turbo-generator units; manufacturers' statements.

Vibration. Axial Vibration of Rotating Steam Turbine Disc Wheels—I, R. H. Collingham. Engineer, vol. 151, nos. 3925–3926, Apr. 3 and 10, 1931, pp. 370–372, and 402–404, 8 figs. Apr. 3: Type of vibration responsible for practically all serious wheel troubles consists of train of backward-traveling waves; question of designer's ability to calculate turbine disk wheel to be free from critical nodal vibration; it is shown how difficult, if not impossible, it is to calculate critical speed of nodal vibration of wheel disk by theoretical considerations alone. Apr. 10: Electrical connections of various exploring coils, electrical circuits of amplifiers used, of oscillograph and of exciting magnet used in tests are shown diagrammatically; outline of procedure followed in developing design of new turbine disk wheels.

STEEL

Cold Working. Cold Working of Steel. Iron and Coal Trades Rev., vol. 122, no. 3285, Feb. 13, 1931, pp. 280–281. Notes on research work at Sheffield University during 1930; drawing of wire of about 0.65 per cent carbon; rolling of dead-mild steel of class used for deep drawing; drawing of rods of about 1 in. diam., material being mild steel.

High-Speed—Hardening. Selecting and Hardening High-Speed Steel, A. Heller. Am. Mach., vol. 74, nos. 17 and 18, Apr. 23 and 30, 1931, pp. 635–638, and 685–688, 11 figs. Apr. 23: Heat treatment and hardening characteristics of cobalt and tungsten steels; graphs illustrate characteristics of three tungsten high-speed steels and two cobalt high-speed steels, showing that latter harden at lower temperature; effect on hardness by soaking at various temperatures for varying lengths of time. Apr. 30: Methods of testing strength and toughness of tungsten and cobalt steels when lower hardening temperatures are used with short soaking periods.

Rustless. See AUTOMOBILES, Steel for.

Tool—Testing. Haerdbrottsundersoekning saasom kvalitetsprovningsmetod foer verktygstaal (The Fracture of Quenched Specimens as a Quality Test for Tool Steel), R. Arpi. Jernkontorets Annaler, no. 2, 1931, pp. 75–95, 6 figs. Investigation to ascertain if fracture of specimens quenched from different temperatures gives reliable indication of quality; specimens compared with scale of 10 fracture classes; while steels with wide quenching range (fine-grained fracture at widely differing quenching temperatures) also show good results when practically tested as tools, narrow quenching range may not necessarily mean inferior quality.

STEEL FOUNDRY PRACTICE

Large Castings. Massive Castings Made With Cores in New Steel Foundry, E. F. Cone. Iron Age, vol. 127, no. 18, Apr. 30, 1931, pp. 1416–1421, 9 figs. Operating methods and equipment at plant of General Steel Castings Corp.; at Eddystone, Pa.; plans illustrate layout of shop and buildings; casting of locomotive beds, and tank-car frames.

STOKERS

Design. Progress in Stoker Design. World Power, vol. 15, no. 88, Apr. 1931, pp. 330 and 333, 2 figs. Features of modern multiple-retort stoker contrasted with traveling-grate stoker; design, construction, and operation of Taylor stoker.

T

THERMODYNAMICS

Reversed Carnot Cycle. 2-Mill Commercial Heat by Reversing Refrigeration Cycle, W. R. Chawner. Elec. West, vol. 66, no. 4, Apr. 1, 1931, pp. 177–179, 2 figs. Practical application of reversed Carnot cycle makes available 5 B.t.u. of commercial heat for expenditure of 1 B.t.u. in mechanical work.

TRACTORS, AGRICULTURAL

Design. General-Purpose Tractor Design, G. D. Jones. Agricultural Eng., vol. 12, nos. 3 and 4, Mar. 1931, pp. 91–92, and Apr. (correction), p. 139. Comments on future development and design; future general-purpose tractor will be completely balanced with as much of weight as possible during pulling operation carried directly over drivewheels, and more or less evenly distributed over entire tractor when operating without load; with means for widening and narrowing tread and for raising and lowering clearance and center of gravity; complete visibility with perhaps two seats, and simple, easily operated steering means.

TURBO-COMPRESSORS

Large. Large Turbo-Compressor Set for Rosherville Generating Station, D. Marples. Brown Boveri Rev., vol. 18, no. 4, Apr. 1931, pp. 139–146, 10 figs. Equipment described is largest in world; volume of air to be delivered, measured at suction conditions is 132,000 cu. m. per hr.; atmospheric pressure is 0.85 kg. per sq. cm. abs.; delivery pressure is 9.5 kg. per sq. cm. abs. speed is 2700 r.p.m.

Theory and Design. Nye Omraader for Anvendelsen af Turboblaesere og Turbokompressorer (New Fields of Application for Turbo-Blowouts and Turbo-Compressors), Landsbergs. Tekniske Forenings Tidsskrift, vol. 55, no. 2, Feb. 1931, pp. 15–39, 19 figs. Theory and design of turbo-compressors; practical examples illustrate use of turbo-compressors in pneumatic transportation system, in blast furnace operation, and refrigerating system; turbo-blowers as superchargers of Diesel engine and in gas pumping stations.

W

WAGES

Wage-Payment Plans. Department Analyses and Wage Incentives. W. G. Uhlir. Maintenance Eng., vol. 89, no. 4, Apr. 1931, pp. 175–178. How to analyze department; distinction between work and results; application of wage-incentive payment to electrical maintenance task; form of ruled sheet for department analysis, extra commission earned, and bonus analysis.

WELDING

Boilers. See BOILERS, Welding.

Electric. See ELECTRIC WELDING.

WELDS

Strengthening by Butt Straps. The Strengthening of Welded Joints by Cross-Straps, E. Hoehn. Engineering, vol. 131, no. 3405, Apr. 17, 1931, pp. 525–526, 5 figs. Welded joints for steam boilers, containers, and other pressure vessels should be reinforced; these are best arranged on opposite sides of plating with outer strap directly over inner; plates tested were 160 mm. wide and from 12 to 13 mm. thick; straps were welded on to these at middle; it has been shown that such straps properly applied may be relied upon to reduce stress on welded joint by 30 per cent or more.

Testing. Ueber Dauerpruefungen von Azetylen-Schweissungen (Fatigue Testing of Acetylene Welds), Baumgaertel. Autogene Metallbearbeitung, vol. 24, no. 6, Mar. 15, 1931, pp. 81–87, 8 figs. Design and operation of various types of German fatigue-testing machines, including types of Schenck, Foeppl-Heydekampf and M.A.N.; experimental investigation of welded tubing; reference to work of R. R. Moore.

WIND TUNNELS

Variable-Density. The Variable Density Tunnel for the National Physical Laboratory, A. J. Grant. Engineer, vol. 151, nos. 3927 and 3928, Apr. 17, 1931, pp. 427–429, and Apr. 24, pp. 466–468, 9 figs. Difficulties experienced by builders, John Brown & Co., in meeting requirements of National Physical Laboratory authorities, and various methods adopted to overcome them; internal structure.